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SUPPLEMENT TO "THE ELECTRICIAN," NOVEMBER 3, 1893.

Pages 55 to 502 - 517 - 523

THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

VOLUME XXXI.

FROM MAY 5, 1893, TO OCTOBER 27, 1893.

LONDON:
Printed and Published for the Proprietors by GEORGE TUCKER, at the Offices of "THE ELECTRICIAN," Salisbury-court, Fleet-street, E.C.

1893.

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Supplement to Volume XXXI.

May 12th, 1893 ... ... STEEL PLATE PORTRAIT OF SIR JAMES ANDERSON.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 781.—Vol. XXXI. FRIDAY, MAY 5, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

The elaborate Paper by Mr. Albion Snell on "The Distribution of Power by Alternate-Current Motors" has led to so good a discussion that we have given a rather more full report than usual. The remarks of most of the speakers were restricted, for a wonder, to the ostensible subject of the Paper, and did not wander off into details of motors. The very sensible views expressed by Mr. Mordey and others were confirmed by Mr. A. Siemens. *Drehstrom* motors and other more or less complicated expedients are, however, worth examining, and it is fortunate, perhaps, that those who, like Mr. Snell, have studied them, and others, like Mr. Brown, who have experimented with them, should so freely publish information on the subject. We have been blamed for a lack of enthusiasm about the *drehstrom* system, though we have always admitted that it may prove to be very useful in certain simple cases of transmission; as it is, the strict subject of Mr. Snell's Paper, the *distribution* of power by alternate-current motors, seems as far off as ever.

Uses for electric motors are being gradually developed, but as yet the filling up of the load curve of supply stations can hardly be said to have begun. Among applications which may be said to be in an experimental stage are a refrigerating ammonia plant and an electro-hydraulic lift in Victoria-street, Westminster. The former has been running for some time, and though the work is of a continuous character, suitable indeed for a synchronous alternating motor, it is said to be less costly than a gas engine. The lift is somewhat complicated; a motor drives a three-throw pump; this fills a hydraulic accumulator, and this works two lifts; the accumulator stops and starts the motor. For such work as this alternate currents would seem to be ill adapted.

Mr. Rimington has contributed a number of interesting experiments on vacuum tubes to the already large and rather heterogeneous stock which has been accumulating since the days of Gassiot. We have reproduced one or two of the diagrams from his Paper in our report of the last meeting of the Physical Society. Purely electromagnetic discharges, if we may be allowed to employ so loose a term, seem to be more amenable to scientific treatment than the luminous effects produced by electrostatic conditions. Where these two things are mixed, it is very difficult to follow the actions. The use of tinfoil caps seems to introduce a series of phenomena very different from the simple luminous ring discharges which attracted so much attention when shown before the Physical Society by Prof. J. J. Thomson. We understand that Dr. J. T. Bottomley has found that when such caps are used and are connected to earth, the effects are largely connected with the condition of the tubes—*e.g.*, as to exhaustion—and if the tubes are kept on the pump and not sealed off, differences in the vacuum, and even in the dryness of the outside, and a multitude of small particulars not easy to recognise, will give rise to a corresponding multitude of phenomena very different from those which may at first sight appear to be normal. It is difficult enough to apply mathematical treatment to oscillatory discharges under fairly simple conditions, but it seems very doubtful whether Mr. Rimington's algebra holds good inside tubes in which apparently unclosed circuits are formed in partial vacua. As soon as we get to vacua we find ourselves in a new world, where "bombardments," "Crookes' effects," and other occult varieties of the laws of Nature defy ordinary treatment; nor are we much wiser when we call an apparently electromagnetic luminosity a "discharge," and and an apparently electrostatic one "phosphorescence."

A copy of the official catalogue of the British Section of the Chicago Exhibition has been sent to us, and we congratulate the Royal Commission in adopting this sensible name instead of World's Fair Columbian Exposition. The only exhibits connected with English electrical engineering that call for any remark seem to be the engines by Galloways, Parsons, and Willans and Robinson, and a Siemens dynamo. These, no doubt, worthily represent what other English firms could send if they thought it worth while. An article written by Prof. Ayrton introduces the visitor to the ridiculous Electrical Section. The London Chamber of Commerce and the Institution of Electrical Engineers having failed to receive a single reply to the circulars which they were urged to send out, it is clear that it is by no accident that the English electrical trade does not care to employ this method of cultivating a foreign connection. By dint of repeating the names of the eleven electrical exhibitors, in most cases twice and in one case seven times, nearly four pages of the catalogue are filled with entries and cross references. Prof. S. P. Thompson contributes a chapter on "Instruments of Precision (other than Electrical and Magnetic)." These unfortunate instruments seem thus to be omitted altogether since Prof. Ayrton does not deal with them, but perhaps the Royal Commission did not consider that there was anything

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to say about them, or thought that they were not in use in America. Prof. THOMPSON's chapter is, with others, introductory to "Liberal Arts." The only one of these which in any way concerns us is civil engineering; and this appears from the catalogue to be, if possible, more sorry a show than the Electrical Section. Besides these there is a "Machinery" Section which contains the names of four or five well-known firms and a number of the class who are only heard of at exhibitions.

THE withdrawal by the Corporation of the pecuniary support it has hitherto given to the City and Guilds of London Institute, a step adverted to in a somewhat oversolemn tone at the annual meeting of the Governors last week, is important rather as tending to lessen the prestige of the Institute than as placing it in financial straits. Since the commencement, the City Guilds and others have given £405,097. 4s. 6d. in support of the Institute connected with them. To this grand total the Corporation of the City of London has contributed £14,500 or rather less than 4 per cent. A contribution of this modest character is, we suppose, what is known as moral support.

THERE may be, and there are, two opinions as to the results likely to accrue from the present tendencies of the college training of engineers. Most of us agree, however, that little but good can come of the scientific training of those who may be called the non-commissioned officers of our industrial army. To those in daily contact with hard facts, a tincture of the science underlying their occupation is at once an intellectual relaxation and an addition to their utilitarian equipment. That being so, it is to be regretted that the Corporation has been obliged to forego the pleasure of forwarding so good a cause. Of course it may intend to apply the money elsewhere to a greater advantage, but of this, so far as we know, there is no suggestion.

THE manifest one-sidedness of the "Birkenhead" clause has been in a measure mitigated by the qualifying addendum introduced in a Provisional Order authorising the construction of a tramway system at Great Yarmouth. Traction and telephony will not be on an equal footing until protection is granted to telephone circuits only when they have been doubled and run with due regard to the prevention of ordinary every day induction. We print the clause in question in another column.

WITHOUT infringing the rules of the Institution of Civil Engineers as to publication of their proceedings, we may, perhaps, observe that the question of cycles, impulses, and direct driving, referred to by Mr. MCMULLEN in our Correspondence columns, was fully discussed after the reading of Mr. Dowson's Paper on January 10, 1893, although the particular case of alternators running in parallel was not considered. With reference to our correspondent's concluding suggestion, we are inclined to doubt whether any engines for electric supply, either gas or steam, should be run as low as half load, unless on exceptional occasions, and we are not aware that any success has attended attempts to vary the power of the explosions of gas engines. If alternators are run in parallel there should be no occasion for running on half load. Mr. SWINBURNE has pointed out that the use of governors, at all events separate governors, on the engines is disadvantageous in running alternators in parallel, and other engineers have rediscovered this fact. For non-parallel running, where the plant cannot be kept fairly well loaded by fidgeting with the switches, good governing is essential. One or two makers of gas engines seem to be fully alive to the necessity for continuous impulses. A gas engine is costly compared with a steam engine, and this is to some extent due to the idle strokes. If the impulses could be increased without the extra cost of hollow piston rods and additional cylinders, gas engines would, no doubt, be much more applicable to direct driving. But this is a mere truism, and is hardly a suggestion for which engine builders need be thankful.

MR. SIDNEY WALKER's long letter, which will be found in our Correspondence columns, begins with a few well-meant suggestions for the conduct of technical journals. Mr. WALKER seems to expect them to teach young or ignorant electrical engineers and electricians the common knowledge of their trade. Of all the ill-advised methods of imparting such knowledge, "articles in technical journals and Papers read before scientific societies" are, in our opinion, the worst. We occasionally provide articles for our younger readers dealing with elementary principles, and some time ago described the construction of a few simple instruments; these latter were to facilitate rough experimental work, not to teach instrument making. Mr. WALKER's favourite kind of technical journal would seem to be those wonderful publications which give their readers "Hints on making a handy howdah," "How to build a cathedral," "Notes on gilding wheelbarrows."

MR. WALKER suggests that oil paint and knotting "contain metallic bases which will be deposited by the leakage current," but does not say whether he has ever found a vestige of such deposition. His experience with insulated cables seems unfortunate; and believing, as we do, that fairly good qualities of insulation are not liable to the numerous defects of which Mr. WALKER complains, we can only conclude that in addressing himself only to "those who do not understand and who do bad work in consequence" he is at the same time discussing the use of bad materials.

WIDE as is the range of that group of sciences which is known as Physics, and notwithstanding its numerous practical applications, no purely scientific journal has yet been devoted to it. There are French and German periodical publications which form valuable records of research, and resemble in some respects our *Philosophical Magazine*. A periodical devoted to Physics does not appeal to a very wide circle of readers, and having but little commercial backbone, would probably fail to secure those pages of advertisements which are essential to the vitality of any urnal. A publication of this description is, nevertheless,

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needed by physicists, and we have, therefore, great pleasure in announcing that Prof. E. L. NICHOLS and Prof. E. MERRITT, of the Cornell University, propose to start a fortnightly journal of experimental and theoretical Physics, to be called the *Physical Review*. We understand that the Cornell University will give the necessary financial support, and the names of its editors are sufficient to promise that the *Physical Review* will be a valuable addition to scientific literature.

No improvement can be reported as to Sir JAMES ANDERSON'S condition, which remains most critical.

Electric Railway Schemes for Berlin.—An electric railway scheme has been drawn up by Messrs. Siemens and Halske, and it is hoped that a concession will be shortly granted to this firm.

Royal Society.—The following Paper was down for reading before the Royal Society yesterday:—Profs. Reinold and Rücker, "On the Thickness and Electrical Resistance of Thin Liquid Films."

Cheap Telegrams.—In answer to a memorial from the Associated Chambers of Commerce, the Postmaster-General stated that, in the face of the deficiency in the telegraph revenue, he could not hold out any prospect of a further reduction of tariff.

Cable Interruptions.

	Date of interruption.
Para-Maranham	March 20th.
Paramaribo-Cayenne	April 15th.
Santiago de Cuba-Mole St. Nicholas	April 20th.
Gibraltar-Tangier	April 29th.

Electrical Bills in Parliament.—In the House of Commons on Monday last the Brighton and Rottingdean Seashore Electric Railway Bill was read a third time. On Tuesday the City and South London Railway Bill was read a third time, and the Barry Railway Bill was recommitted.

Antwerp.—The Antwerp Hydro-Electric Company, which, in carrying out the scheme of the late M. Van Rysselberghe of supplying high-pressure water to turbo-dynamos placed in sub-stations has to convey water at 30 atmospheres pressure, is using Mannesmann tubes for the purpose.

Steam Pipe Radiation.—According to results obtained at the physical laboratory of the Technical School of Chemnitz, the loss of heat by an iron pipe 4in. in external diameter, and conveying steam at 75lb. atmospheres pressure, is 1,530 kilogramme-calories per square metre per hour. This is equivalent to $2\frac{1}{3}$ H.P.

Personal.—M. Gaston Roux, the assistant editor of our esteemed French contemporary *L'Industrie Electrique*, and Chef des Travaux Pratiques d'Electricité à l'Ecole Municipale de Physique et de Chimie Industrielles, has been appointed consulting engineer to the Compagnie Française pour l'Exploitation des Brevets Thomson-Houston.

Telephone Wires.—The Corporation of Edinburgh, having objected to the right of the National Telephone Company to oppose their Improvements Bill, the question was considered by the Court of Referees. The Court has decided to give the Telephone Company a right to appear in order to claim compensation for any interference with their wires affixed to buildings of which they are not the owners.

Electrotechnics.—The glut of highly-trained electrotechnical men seems as depressing in France as elsewhere. M. Darras, in a recent number of *L'Industrie Electrique*, bewails the present state of the French electrical industry, which is, he says, a mere appanage of Switzerland and Germany, and asks if it is wise to go on turning out a product so little in request as "*ingénieurs d'une culture supérieure.*"

Edinburgh.—At the last meeting of the Town Council Bailie Walcot moved the disapproval of the minutes of the special meeting of April 21st, with reference to the city taking over the management of the electric light. There were in the Council, he said, 11 unrecorded votes. If these 11 supported him the majority of the Council would be in favour of his motion. After a discussion, lasting for an hour and three-quarters, a vote was taken, when the minutes were approved by 19 to 16.

The Telephone at Liverpool.—The largest telephone switch-room in the United Kingdom, and one of the largest in Europe, is that at Liverpool, where the National Telephone Company have just completed a new one. There are worked from the Liverpool centre 9,600 miles of wire, of which more than 7,000 are exchange and private wires. In 1882 the mileage of wires in Liverpool was only 463 miles; in February last it was 7,019. From the last published statistics it appears that the number of "calls" in the Liverpool centre is 42,800 per day.

Railway Telegrams.—On Tuesday last, on the consideration of the Great North of Scotland Railway Bill, a clause was inserted, on the motion of Mr. Arnold Morley, to provide that nothing in the Act should be deemed to impose upon the Postmaster-General the obligation of transmitting, under the provisions of the Telegraph Act, 1868, or any agreement between the Postmaster-General and the Company made in pursuance thereof, any larger number of telegraphic messages of the Company free of charge than he would have been bound to transmit had this Act not become law.

The Chicago Exhibition.—The American Society of Civil Engineers has addressed the following letter to the Secretary of the Institution of Electrical Engineers:—

DEAR SIR: In view of the probability that members of your Society will visit this city *en route* to the Columbian Exposition, the American Society of Civil Engineers has appointed Edward P. North, L. L. Buck, and Foster Crowell a Committee of Information and Courtesy at this house. This Committee will endeavour to furnish all engineers accredited by your Society with information as to rates, localities, and engineering works of interest. Please address such credentials and all correspondence on this subject to the Committee of Information and Courtesy, American Society of Civil Engineers, 127, East Twenty-third-street, New York City.

Overhead Wires at Middlesbrough.—At a recent meeting of the Streets Committee of the Middlesbrough Corporation consideration was given to an application to carry overhead wires from one hotel to another for the purpose of lighting both premises with electricity. The Mayor said he had discussed the subject with an electrical engineer, who informed him that the Corporation would do wrong if they gave permission to carry electric wires overhead. These overhead wires were a considerable danger, and "owing to the enormous current passing through them, they were in the habit of breaking"! It was decided to reply that the Corporation would not on any consideration allow overhead electric wires to be erected in the town.

Hanley.—At the quarterly meeting of the Town Council held on Tuesday last, the General Purposes Committee recommended that 30 1,200-c.p. arc lamps, instead of 20 of 2,000 c.p. each, be provided for the purpose of street lighting, principally in substitution for the large gas lamps, and that the electric light mains be laid for the purpose of the street lighting by incandescent lamps at the same time as the other mains, to replace the remaining gas lamps. The recommendations were confirmed. On the recommendation of the Electric Lighting Sub-Committee it was decided to advertise for an electrical engineer to have charge of the construction of the works, and the management of such works when completed, at a salary of £200 a year.

The Fellowship of the City and Guilds of London.—The Council of the City and Guilds of London Institute have elected Mr. H. A. Humphrey a Fellow of the Institute. This distinction is conferred upon those who, having matriculated and successfully completed the course of instruction prescribed for regular students at the Central Institution and obtained the diploma of Associate, shall have spent not less than five years in the practice of their profession, and shall produce evidence of having done some original and valuable research work, or of having otherwise contributed to the advancement of the industry in which they are engaged. Mr. Humphrey obtained the diploma of Associate in 1887, and is now engineering manager of the refined bicarbonate and crystal plant departments of Messrs. Brunner, Mond, and Co.

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Cutting an Atlantic Cable.—In the House of Commons on Tuesday evening, Mr. H. Plunkett asked the Chief Secretary whether he was aware that the Atlantic Cable was cut near Ballycarbery, County Kerry, the week before last; whether he was aware that the tenant through whose land the cable ran demanded and received a sum of £20 before he would allow the Company's men to repair the cable; and whether, considering the great inconvenience caused to the public by such acts, he would take steps to see that their recurrence was prevented. Mr. J. Morley replied that the facts mentioned were substantially correct. It appeared that a sum of £25 was paid to the tenant on behalf of the Company in settlement of his claim. He (Mr. Morley) was not quite sure to what extent the Government had either power or duty in a matter of that kind, but it was now under consideration.

Water Power in Ireland.—The water power of the River Flesk, Killarney, has been used for over a century for working some flour and corn mills. Some time ago the proprietor, Mr. Chas. E. Leahy, applied for a Provisional Order for the lighting of the town of Killarney. A company was formed, and Mr. Victor A. H. M'Cowen was appointed to prepare plans, and carry out the work. The works are now almost completed, and houses are being wired. The current is transmitted from the generating station to a central switch station in the town (a distance of about a mile) at 2,000 volts. Three separate high-pressure circuits supply the town from the centre. Low-pressure mains fed from tranformers placed under the footway supply the consumers. The price charged is to be 6d. per unit. Since the Company has started, the price of gas has been reduced from 7s. 6d. per 1,000 to 5s. 9d.

The Bessbrook-Newry Electric Railway.—An accident of a serious nature occurred on the Bessbrook and Newry Electric Railway on Saturday last, about three o'clock. The car conveying passengers, to which were attached some waggon loads of linen and other goods, was proceeding from Bessbrook to Newry when one of the waggons by some means overturned and fell down the bank. A gang of men, with a lorry and the necessary breakdown appliances, proceeded to the scene of the accident, and at once commenced to clear the line. On the arrival of the electric car from Newry on the return journey, the lorry, which is lower than the electric car, was being pushed towards Bessbrook, when shortly after the start it got underneath the engine and car, throwing them off the rails, thus blocking the line again. The passengers in the cars received no injury whatever, and got out and walked to Bessbrook. The line, however, was blocked all the evening.

A Telephone Protection Clause.—Clause 10, Sub-section 1, of a Provisional Order, authorising the construction of a system of tramways in Great Yarmouth, runs as follows:—

The promotors shall so construct their electric circuits and other works of all descriptions, and shall so work their tramway in all respects as not injuriously to affect the working of any existing electrical circuits from time to time used or intended to be used for the purpose of telegraphic, telephonic or electric signalling communication, or the currents in such circuits, and shall use every reasonable means in the construction of their circuits and other works of all descriptions, and in the working of their undertaking, to prevent injurious affection, whether by induction or otherwise, to any electric circuits used or intended to be used for the purposes aforesaid (whether existing at the time of the construction of the electric circuits or other works of the promoters or not), or the currents in such circuits.—Provided that, as regards electric circuits erected or laid down by other parties than the promoters after the construction of the works of the promoters, this sub-section shall only apply if, in the erection, laying down and working of all such circuits, reasonable and proper precautions against injurious interference with other electric circuits have been taken, and if they have not been erected or laid down in unreasonably close proximity to the lines or works of the promoters.

Electrical Communication with Lightships. — In answer to a question put by Mr. E. H. Bayley the other night in the House of Commons, the Postmaster-General said that his department had no official knowledge of the circumstances attending the wreck of the "Enterkin," but it would appear that telegraphic communication with the Sunk Lightship would not have been of any avail to prevent the sad loss of life which then took place. The wreck appeared to have taken place on the North Galloper Sands, which were at a great distance from the Sunk Lightship, and the signals of distress did not appear to have been noticed at that lightship. He reminded the hon. member, however, that the whole question of telegraphic communication with lightships had been referred to a Royal Commission, whose first report had been presented to Parliament. The hon. member would see, on reference to that report, that the immediate restoration of communication with the Sunk was not proposed, but that telegraphic communication with the Kentish Knock Lightship was recommended. The Kentish Knock was much nearer the scene of the wreck of the "Enterkin."

Obituary.—We regret to record the death at sea, from coast fever, on April 30th, of Captain C. Bulmer Morfee. He entered the Eastern Telegraph service in 1882 as third officer, and rose step by step until he was appointed to the command of the Eastern and South African Company's cable steamer "Great Northern" in 1889. The deceased, who was very popular both on board his ship and in the service, was only 35. He was buried at sea between Brass and Principe, on the West Coast of Africa. An additionally sad feature of the case is that at the time of his death his wife was on her way to join him at the ship's station at Cape Town.——We regret to have to announce the death of Mr. Walter T. Glover, of the well-known firm of Walter T. Glover and Co., electrical wire makers, Salford. Mr. Glover had been out of health for several years. He was one of the few men who had the boldness to think and to say that the much-abused Electric Lighting Act of 1882 did more good than harm, inasmuch as it prevented the perpetration of a lot of crude electrical engineering. Mr. Glover was one of the first to realise the necessity for accurate tables of the resistance and weight of electrical conductors; and his tables practically held the field until the introduction of the standard wire gauge. Mr. Glover at one time took a very active interest in local affairs.——The death is announced at the age of 55 of M. Frank Géraldy, vice-president of the Société pour la Transmission de la Force par l'Electricité.

The City and Guilds of London Institute and the Corporation.—At the ordinary general meeting of the Governors of the City and Guilds of London Institute, last week, Lord Selborne, in moving the adoption of the annual report presented by the Council, said the Institute was approaching the *maximum* of its capacity, so far as some of the classes were concerned. The total number of the day and evening classes was 1,912. In the Central Institution the students numbered 199. In the Finsbury College there had been an increase of students from 198 last year to 213. He reminded those present that this was the last year in which the Council proposed to continue the large and liberal system of grants to technological examinations, as far as the country districts were concerned. The Council would, however, continue its assistance to London. With regard to the withdrawal of the support which the Corporation had hitherto given to the operations of the Institute, it was not for him to say what reasons had influenced the Corporation, but the subject was to him a very painful one. The paragraph relating to this matter, from the report of the Council, was as follows:—"The Council regret to report that the Corporation of London have withdrawn their financial support from the Institute. It may be remembered that the transfer of the classes of the City School of Art to the Technical College, Finsbury, was effected at the instance of the Corporation, and within the last few years the Institute had been at some considerable expense in improving the efficiency of this department of the College by laying down plant for lighting the studios by electricity. Although the contribution from the Corporation to the funds of the Institute has for several years been uncertain, its withdrawal at the present time, when the Council were looking forward to further extend the College, is most inopportune. The Council cannot help expressing regret that, at a time when all other large municipal bodies are actively taking up the question of the provision of technical instruction in their towns, the Corporation of London should be the one to withdraw altogether their contribution towards this object." In conclusion, Lord Selborne pointed out that there was a decrease in the income of the Institute for the current year. Last year the income was £33,093, and the expenditure £31,267, showing, therefore, a balance of £1,826. The estimated income for the present year was, however, £31,810.

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ELECTROMAGNETIC THEORY.—XLIX.

BY OLIVER HEAVISIDE.

(Continued from page 709, Vol. XXX.)

§ 198. We are now prepared to somewhat understand the nature of the changes suffered by electromagnetic waves in transit through a conducting medium. It being the distortion due to the conductance alone that is in question, we eliminate that due to other causes by choosing plane waves for examination, since these do not suffer any distortion in a homogeneous dielectric when it is non-conducting. Imagine, then, a simple electromagnetic plane wave-sheet of small depth to be running through a dielectric at the natural speed conditioned by its inductivity and permittivity. At any stage of its progress, let the medium become slightly electrically conducting all over, not merely in advance of the wave but behind it as well, for a reason that will presently appear. What happens to the wave now that the fresh influence is in operation?

A part of the answer we can give at once, by the previous. The wave-sheet will move on just as before, but will attenuate as it goes, according to the time-factor $\epsilon^{-kt/2c}$. Since we suppose the conductivity to be slight, it follows that a great distance may be traversed before there is notable attenuation. We also know that the total induction remains constant. The rest of it—that is, what is not in the sheet at any moment—is therefore left behind. The rejecting process commences the moment the conductivity is introduced, and continues to act until the plane wave is attenuated to nothing. The rejected portions travel backwards. But they are themselves subject to the same laws as the main plane wave, and so get mixed up. The result is that at time t after the introduction of the conductivity, the whole region of disturbance is spread over the distance $2vt$, half to the right and half to the left of the initial position. At the advancing right end we have a strong condensed disturbance, viz., the original wave attenuated, and behind it a weak diffused one. We can therefore, without misunderstanding refer to them as the head and the tail, without any body to complicate matters. Now the nature of the tail is quite different as regards the displacement and the induction. It is therefore convenient to regard one of them alone in the first place, and, of course, we select the induction, on account of the simple property of persistence that it possesses. We can distinguish three or four different stages in its development.

The first stage is when the attenuation of the head is not great, say, whilst the head decreases from 1 to 0·75. Whilst this occurs, the total induction in the tail rises from 0 to 0·25. The tail is long and thin, and tapers to a point at its extreme end, or tip, at distance $2vt$ behind the head, and is thickest where it joins on to the head.

The second stage roughly belongs to the period during which the head further attenuates from 0·75 to 0·5 or 0·4. The total induction in the tail then increases from 0·25 to 0·5 or 0·6. During this stage we find that the tail, which has, of course, greatly increased in length, does not go on increasing in thickness at the place where it is developed, but stops increasing and shows a maximum at or near that place.

The third stage occurs during the further attenuation of the head to, say, 0·1, whilst the total induction in the tail increases to 0·9. The maximum thickness of the tail is now a long way from the head, and at the end of the stage is nearer to the middle than to the head. Of course, since the head itself is now so small, the additions made to the tail must also become smaller.

The fourth stage is when the head practically disappears and all the induction is in the tail. The maximum thickness is now nearly in the middle—on the right side, however—and the tail is nearly symmetrical with respect to its middle, where there is a swelling, beyond which the tail tapers off both ways to its two tips.

The final state is the consummation of the previous, and is one of perfect symmetry with respect to the middle of the tail, which is situated exactly where the plane wave was when the spreading began. The spreading now takes place according to the pure diffusion law, as of heat by conduction.

Now as regards the displacement in the head and tail in the different stages. In the first and second stages the displacement is wholly negative in the tail, assuming it to be positive in the head, where, it should be remembered, it attenuates in the same manner as the induction which accompanies it. Thus, when the head has fallen to 0·9, the total displacement in the head and tail has fallen to $(0·9)^2$ or 0·81, so that the total negative displacement in the tail is of amount 0·09, which is not much less than the coincident induction. And when the head has attenuated to 0·8, and the total displacement to $(0·8)^2$ or 0·64, the negative displacement in the tail amounts to 0·16. But, unlike the induction, the displacement increases in the tail from the head up to not far from the tip, where, of course, it falls to zero. There is no tip at the forward end. But as the tail stretches out further to the left, and has fresh additions made to it on the right side, the decrease of the density of displacement in passing towards the head continues, until somewhere about the end of the second stage, it becomes zero next the head. This node is approximately at the place where the induction has its maximum. When the head has fallen to 0·4, we have the total displacement attenuated to 0·16, so that the negative displacement in the tail amounts to 0·24.

In the third stage the displacement is negative from the tip up to somewhere near and beyond the maximum of induction, and increasingly positive in the remainder, up to the head. That is, the region of positive displacement now extends itself from the head a good way into the tail. At the same time the place of maximum negative displacement moves forward.

During the fourth stage, the place of maximum negative displacement shifts itself to nearly the middle of the region between the tip and the node, beyond which the positive displacement has a nearly similar distribution, with a maximum. But this positive distribution is only three-parts formed, as the head is still of some importance. The fifth stage completes the formation of the tail, with the displacement negative in one half and positive in the other, and nearly symmetrical with respect to the middle. Finally, we come to a state of perfect symmetry, with one maximum of induction and two (or a maximum and a minimum) of displacement. This may be readily understood by considering that in the expression for the true electric current, $k\mathbf{E}+c\dot{\mathbf{E}}$, the second term finally becomes a small fraction of the first, or the current is practically the conduction-current only. Then $\mathbf{E}$, and therefore the displacement, is proportional to the space-variation of the induction. Owing to the tail being made up of a complicated mixture of infinitesimal electromagnetic waves going both ways, we lose sight of the fundamental property of elastic wave-propagation in a dielectric, the resultant effect being propagation by diffusion now, or very nearly so. The approximation to this result is closest in the middle of the tail. At the tips, on the other hand, we still have elastic waves, but, of course, of insensible strength.

Now, suppose that the initial state is one of induction only, though still in a plane sheet. It may be regarded as the coincidence of two plane electromagnetic sheets of half the strength, with similar inductions and opposite displacements. The subsequent history may, therefore, be deduced from the preceding. The initial induction splits into two halves, of which one moves to the right at speed v, and the other to the left. The history of the first wave as distorted by the conductance has been given. That of the second wave is the same, if we allow for the changed direction of motion and sense of the displacement. So we have only to superpose the two systems to show how an initial distribution of induction in a plane sheet splits and spreads, and the accompanying electric displacement. We have two equal heads, separating from one another at speed $2v$, whilst the two tails unite to make a stouter kind of tail (referring to the induction) joining the two heads. This tail is always thickest in the middle. In fact, the distributions of induction and displacement are symmetrical with respect to the initial position from the first moment. In the final state that is tended to, when the tails have vanished, the induction is distributed in the same way as in the former case, in spite of the remarkable difference in the initial phenomena.

If, again, the initial state is one of displacement alone in a plane sheet, this generates two oppositely-travelling electro-

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magnetic waves in which the displacements are similar and the inductions are opposite. The result is therefore to be got by combining the previous solution for a wave of positive induction and displacement moving to the right, with a similar wave of negative induction and positive displacement moving to the left.

Whatever be the magnitude of the conductivity, if finite, the same phenomena occur during the conversion of elastic waves to diffusion waves, and they may be represented by the same diagrams, if suitably altered in the relative scale of ordinates and abscissæ. But by increasing the conductivity from the small value which makes the above-described process take place over a considerable interval of time, we make it occur in a small interval only; and when we come to what are usually considered good conductors, viz., metals, then the interval of time is so small that we may say practically that the heads vanish almost at once, and before the propagation has proceeded any notable distance. The rest of the story is the spreading by diffusion or mixture. Thus we have an important practical distinction between the very good and the very bad conductor, as regards the manner of propagation of induction. In the former the electric displacement is of no account hardly, except perhaps for very short waves, and the practical theory is the theory of diffusion. At the other extreme are perfect non-conductors, in which the propagation is entirely by elastic waves. Between the two we have, in bad conductors, a mixture of the two kinds, though with a continuous transition from one kind to the other. The mathematical treatment of elastic waves is the easiest. The next in order of difficulty are the waves of pure diffusion, by the ordinary Fourier mathematics. The most troublesome are the intermediate forms of changing type, and the full analytical results are best got by a generalised calculus. But the general nature of the results may be obtained approximately by easy numerical calculations, with diagrammatical assistance. This is explainable without difficulty, and may be entered upon later on, when we come to detailed problems.

In the above the conductivity has been electric only, and we have seen that there is a great difference between its effects on the electric and on the magnetic flux, which arises from the positive reflection and persistence of the latter, and the negative reflection and subsidence of the former flux. The corresponding effects in a magnetic conductor may be readily deduced by the proper transformations, and exhibit analogous differences. Thus, starting with a pure plane wave sheet moving to the right, it is now the displacement that is conserved and divided between the head and tail, being initially all in the head, and finally all in the tail. On the other hand, the induction is negative in the tail at first and until the attenuation of the head is considerable. After this, the region of positive induction extends from the head into the tail. As time goes on, and the head disappears, we have negative induction in one half and positive in the other (forward) half, whilst the displacement is positive all along it, with its maximum nearly in the middle. In the final state of diffusion we have symmetry with respect to the initial position of the wave, and the induction is proportional to the space-variation of the displacement. The second term of the magnetic current $g\mathbf{H}+\mu\dot{\mathbf{H}}$ is then a small fraction of the first term.

Now, in the medium with duplex conductivity we must take the distortionless condition for the standard state. When this obtains there is no tailing, although the head (displacement and induction together) attenuates according to the time-factor $\epsilon^{-kt/c}$. But if the electric conductivity be in excess (that is, greater than is required to make $k/c=g/\mu$) there is tailing of the kind described as due to electric conductivity, with the induction positive and the displacement negative in the tail at first. And if the magnetic conductivity is in excess, the tailing is of the other kind, with positive displacement and negative induction at first. But of course the details are not the same, because both the fluxes now attenuate to zero in time, in the tail as well as in the head.

§ 199. We must now endeavour to give a general idea of the tailing of waves when they run along conducting wires, in co-ordination with the previous. In the first place, observe that although the lines of electric and magnetic force in a pure electromagnetic sheet in ether must be always perpendicular to one another, yet they need not be straight lines, except in their elementary parts. On the contrary, we may have an infinite variety of distributions of the electric and magnetic fluxes in curved lines in sheets which shall behave as electromagnetic waves. Keeping to plane sheets, we may take any distribution of displacement in a sheet that we please, and make it an electromagnetic wave by introducing the appropriate distribution of induction, also in the sheet. If left to itself it will move through the ether one way or the other at speed v, according to the directions of the fluxes. It should be noted, however, that the fluxes should have circuital distributions. For if not, and there is electrification or its magnetic analogue, they, too, should be moved through the ether so as to exactly keep up with the wave. If the electrification does not move thus, we have a changed state of things. But there is a way out of this difficulty. Let the displacement, when it is discontinuous, terminate upon infinitely-conducting lines, or surfaces of cylinders, according to circumstances. The interference produced by holding back the electrification will then be done away with. It is sufficient for explicitness to take a single definite case.

Let the displacement in a plane electromagnetic sheet terminate perpendicularly upon a pair of perfectly-conducting cylindrical tubes placed parallel to one another. One is for the positive and the other for the negative electrification. The induction will then go between and round the tubes. One tube may enclose the other, but, preferably, we shall suppose this is not the case, so that our arrangement resembles a pair of parallel wires. Now the wave will run through the ether in the normal manner, without distortion or change of type, and will carry the electrification (on the conductors) along with it.

Similarly if the tubes be magnetic conductors, if the induction terminates perpendicularly upon them, whilst the displacement goes between and round them. So far, then, the theory of the propagation of the wave is unaltered.

But this property may be greatly extended. The medium outside the tubes through which the wave is moving may be made electrically conducting. The theory is then identical with that of § 198, as regards the distortion produced and the gradual destruction of the wave, ending in the process of diffusion. This will be true whether the tubes are perfect electric or magnetic conductors, provided we have the displacement terminating upon them in the first case and the induction in the second.

Again, if the medium is magnetically conductive, the theory still holds good, with the same reservations as regards terminating the fluxes. But now the distortion is of the other kind, with persistence of the displacement and subsidence of the induction.

Finally, the theory is still true when the medium is a duplex conductor, whilst the tubes are either perfect electric or magnetic conductors, according to choice. The distortion is now of the electric or of the magnetic kind, according as k/c is greater or less than g/μ.

But not one of these cases is quite what we want to represent propagation along real wires. The nearest approach is the case of finite electric conductivity in the medium combined with perfect electric conductance of the tubes. If we make their conductance be imperfect, we then come close to the real problem. Now when we do this, the theory, when done precisely, becomes excessively difficult, for two reasons. First, the waves in the ether outside the tubes are no longer plane; and next, the penetration of the disturbances into the substance of the tubes in time by means of cylindrical waves has to be allowed for. The latter is, of course, more necessary when solid wires are in question. A practical working theory is seemingly impossible of attainment by strictly adhering to the actual conditions. But one is possible by taking advantage of the fact that the waves in the ether are very nearly plane under ordinary circumstances. Of this we may assure ourselves by considering that the tangential component of the electric force at the surface of a wire (upon which the penetration depends) is usually a very small fraction of the normal com-

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ponent of the same outside it. The practical course, then, is to treat the waves in the dielectric as if they were quite plane. This does not prevent our allowing for the distorting effect of the resistance of the wires. It has the effect of making our solutions approximate instead of complete. But the important thing is to have a theory that, whilst sufficiently accurate, is practically workable, and harmonises with more rudimentary theories. This is precisely what we do get, as done by me in 1886. The theory is brought to such a form that we may employ it in several ways, according as circumstances allow us to ignore this or that influence. We may, for example, treat the wires as mere resistances (constant), and this is quite sufficient in a variety of applications. Or, using the same equations with more general meanings attached to the symbols, we may find the effects due to the imperfect penetration of the magnetic induction and electric current into the wires when subjected to varying forces at their boundaries, either simple harmonically or otherwise. Furthermore, the theory is in such a form that it admits readily and without change of the introduction of terminal or intermediate conditions of the kind that occur in practice, whose effects are brought in according to the usual equations of voltage and current in arrangements of apparatus.

What we are immediately concerned with here, however, is the connection between this theory and the general theory of waves in a medium of duplex conductivity. When the tubes are so thin that penetration is practically instantaneous (for the wave-length concerned), a constant ratio is fixed (assisted by Ohm's law) between the intensities of magnetic and of tangential electric force at the boundary of the tube, where it meets the dielectric. And when we incorporate this result in the second circuital law applied to any section of the circuit formed by the parallel tubes, we find that the result is to turn it to the form expressing the existence of magnetic conductivity in the outer medium, without resistance in the wires. That is, the resistance of the wires has the same effect in distorting and dissipating the waves outside as the fictitious magnetic conductivity in the medium generally. This is true in the first and most important approximation to the complete theory. It is a point that is not altogether easy to understand, because the magnetic conductivity is fictitious, whereas the resistance is real. This, however, may be noted, that the theory of propagation of plane waves in a medium of duplex conductivity bounded by perfect conductors for slipping purposes, professes to be a precise theory, whereas the other, although concerning the same problem in most respects, professes to be only approximate so far as the influence of the wires is concerned.

(To be continued.)

SOME APPLICATIONS OF ELECTRICITY TO CHEMISTRY.*—III.

BY JAMES SWINBURNE.

The next division of my subject is the electrolysis of gas. The study is new, and even the expression "electrolysis of gas" is unfamiliar; nevertheless, according to the most recent researches, gases are, to all intents and purposes, electrolysed by the electric discharge. It has been known for a long time, however, that oxygen can be converted into a peculiar modification, namely, ozone, by the electric discharge. This substance is of great value as an oxidising agent for use in bleaching and disinfecting. Ozone is now made industrially. An alternating-current dynamo is employed, and the pressure is raised from 10,000 to 30,000 volts, this pressure being applied in an ozoniser. The various ozonisers in use are much the same in principle. If two electrodes were placed close together in, say, oxygen or air, there would be no electrical discharge to speak of until they were brought so close that a disruptive discharge took place. An arc would then be formed, and this is not what is wanted. What is required is some arrangement by which the air can be broken down. If a piece of glass is placed between the electrodes, air may be broken down, and the glass will support the dielectric stress itself so that there is no arc. As the pressure rises from zero the electric displacement in the air and glass increases until stress in the air causes that part of the circuit to break down. The glass then for the moment bears nearly the whole pressure. As glass has a very high specific inductive capacity, it allows a very large electrical displacement in proportion to its thickness and to the pressure applied; it therefore allows a considerable discharge through the air. Immediately the discharge has taken place the air recovers itself, so that there is little or no stress on the air, nearly the whole being on the glass. As the pressure rises more stress is put on the air and on the glass, and the air breaks down again, and so on, until the top of the alternating wave of pressure is reached. As the pressure falls, the glass, being under stress, communicates its stress to the air again and breaks it down in the reverse direction, and so on until the zero of the electric pressure is reached. The alternating pressure thus produces a series of electric discharges, which have here been explained according to the more recent methods of regarding the action of electric stress on dielectrics. In older language it would have been said that the electricity was charged on to the surface of the glass. So far we have spoken of a series of disruptive currents across the air space. Much of this is really oscillatory, so that in the ozoniser there is really an irregular alternating current of very high frequency. In fact, most of the well-known frequency experiments can be shown by means of a glass plate and a high-pressure transformer.

Practically the ozoniser has two plates of glass, the disruptive discharge taking place between them, the electrodes being on the outside. By this means the contact of the ozone with the metals is avoided. The simplest form of ozoniser consists of an inner and outer tube, with one electrode inside the inner tube and the other outside the outer. The air or oxygen to be treated is passed through the annular space between the tubes.

So far we have been considering electrical currents only, and little has been said about electrical energy or electrical power. In electrolysis of water, for example, we have said nothing about the work done in decomposing, say, a pound of water into oxygen and hydrogen. As the quantity of electricity used varies as the quantity of water decomposed, the other factor, the pressure necessary to cause the decomposition, must remain constant, and must be independent of the rate at which the electricity is passed, that is to say, of the current. Of course, there is extra pressure needed to overcome the resistance of the cell and connections, but that is lost; it is not converted into chemical work. The electromotive force necessary to produce electrolysis is of vital importance in commercial work. It is not necessarily proportional to the heat of combination of the radicles set free. This common error cannot be too often exposed.

Electrical power can be used in another way, namely, by locally heating a conductor to a very high temperature. The white-hot filament of an electric lamp is a good example. In its preparation it is heated electrically in contact with a hydrocarbon. This is decomposed, and carbon is deposited on the filament, which is then said to be "flashed" or "treated." The crater of the arc shows the highest temperature attainable with carbon electrodes. It has been pointed out by Prof. Silvanus Thompson that the crater rises to the temperature of volatilisation of carbon, and no farther; but the volatilising point of carbon is a very good temperature to reach. The uniformity of the temperature of the arc permits of an application of electricity to optics; in fact, it gives a standard of light. Prof. Thompson and the lecturer suggested this simultaneously, and the lecturer designed a screen standard. This has now been carried out practically by M. Blondel, and an account has been presented to the French Academy. Mr. Trotter and Prof. Thompson are also engaged on elaborate researches on the same subject.

The electrical furnace, like many other electrical inventions which are supposed to be quite new, was used by Sir Humphrey Davy nearly a century ago, and somewhat later by Staite,

* A course of three "Tyndall" lectures at the Royal Institution.

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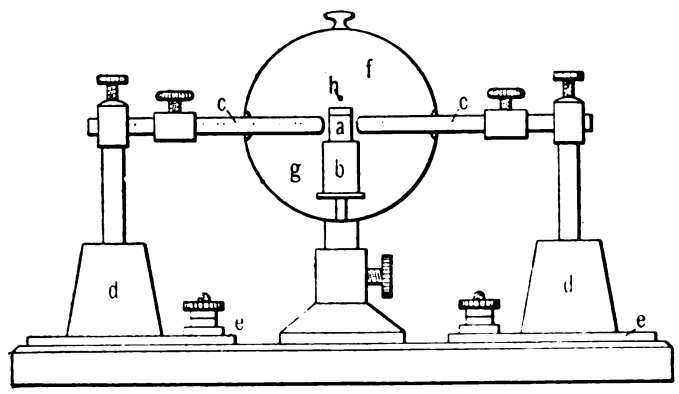
who used the arc furnace for obtaining fused iridium from its oxide for making incandescent lamps.

There are two varieties of the electrical furnace. The oldest is the arc form. A carbon crucible is used, and the arc is allowed to play on the inside from a carbon electrode. This form can hardly be employed on a large scale, but is convenient for laboratory work. The only commercial form is the Cowles, or incandescent electrical furnace. This furnace consists of a mass of carbon, with which the oxide to be reduced is mingled, and a pair of large carbon electrodes. The charge is rendered incandescent by the passage of an enormous current, and when it reaches a certain temperature the oxide is reduced by the carbon. This furnace is used for reducing alumina. The aluminium is difficult to collect, and there is a large demand for aluminium bronze and aluminium iron, so these alloys are manufactured. Mr. Cowles also used his furnace for the reduction of silicon, chromium, boron, and other elements which are with difficulty reduced from their oxides. Mr. Cowles informed the lecturer some years ago that he found his furnace would reduce all the refractory oxides, but aluminium was the only product he considered of commercial value. Quite recently M. Moissan has reduced various refractory oxides by means of the Staite furnace, but it is only fair to Mr. Cowles to state that these results are quite old. This is not the case, however, with M. Moissan's most brilliant achievement, the production of black diamonds. To produce these a mass of iron is heated to a very high temperature by the arc furnace in contact with carbon.



Arc or Incandescent Crucible Furnace.

(*a*.) Carbon Crucible with Carbon Lid. (*b*.) Block of Carbon to support Crucible. (*c c*) Carbon Electrodes. (*d d*) Stands for Electrodes, made to slide on Brass Plates *e e*, so that the Carbons can be easily adjusted without being disturbed by imperfectly Flexible Connections. (*f g*.) Top and Bottom Halves of Containing Sphere. (*h*.) Pinhole for Projecting Image of Crucible on Screen, so that it can be watched.

It absorbs a percentage of carbon. It is then cooled suddenly, and the contraction of the outside of the mass causes enormous pressure in the interior. The carbon which crystallises out in the centre is said to crystallise in the octahedral form, and, in fact, to be black diamond. The Cowles furnace is now used largely for the production of phosphorus from calcium phosphate, by a process invented by Messrs. Readman and Parker.

For experimental purposes the lecturer has devised an arc furnace in which the materials to be operated are not acted upon by the arc directly. A small carbon crucible with a carbon lid holds the material to be treated. It is placed between the tips of two electrodes. The current is started and the electrodes are moved apart so as to allow two arcs to play on the little crucible. This furnace will reduce uranium oxide, alumina, and other refractory oxides. If the electrodes are kept in contact with the crucible an incandescent furnace is obtained. The great advantage of this furnace is that it is easy to control, and that the charge does not get mixed with lime and cannot run away into cooler places in the furnace. The whole is held in a lime body. In another form, shown in the accompanying illustration, the crucible is at the centre of two copper hemispheres, silvered and polished inside. A pinhole in the side allows the image of the hot crucible to be projected on a screen.

[Experiments were made showing the softening point of carbon, the decomposition of hydrocarbon gases and liquids, the production and properties of ozone, and various sorts of electrical furnace were shown. The fusion of platinum, chromium, tungsten, and lime, and the reduction of uranium and other refractory oxides were shown.]

THE "GENERAL" METER.

The principle of the "General" meter resembles that of the well-known Aron meter in that two pendulums are employed, one vibrating under the action of gravity alone, and the other being accelerated or retarded by a magnetic field. But it differs in two important points from differential meters of the Aron type, for the maintaining force does not depend on a wound-up spring, and the recording train is not driven by an escapement. The pendulums are in fact simply swinging bars, kept in motion, only so long as any current is passing through the main coils, by a gravity impulse lever, and this gravity piece is lifted by a shunt magnet, and at the proper moment is allowed to fall against the pendulum (the arrangement being duplicated) The same magnet, in lifting the gravity piece for another impulse, drives the differential counting trains. The function of the pendulums is simply to make and break contacts. The coils of the electromagnets which are employed to lift the impulse weight are joined up with suitable high-

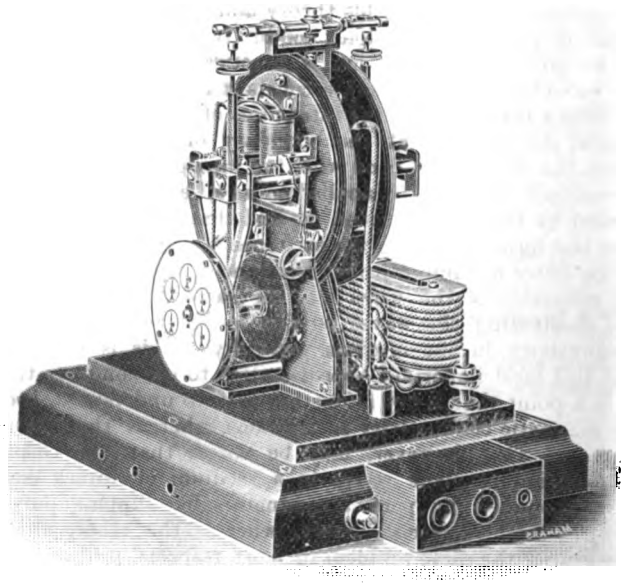


FIG. 1.—The "General" Meter.

resistance coils, and are connected in shunt across the supply mains. The total resistance of these coils of each clock being 6,000 ohms, the current necessary to drive each clock is only one-sixtieth of an ampere, and as this is only required during less than one-half of the swing, and during the time only while the light is used, the cost of driving need not be considered. By a special arrangement of the winding of these coils, sparking at the contacts is suppressed.

The current to be measured passes through a solenoid of special shape, the resistance of which is extremely low, placed immediately below the magnet-bar, and which it influences as stated before. The lower pole of the solenoid acts upon a light pivoted magnetic needle, so that directly a current passes through the turns of the solenoid the needle is deflected, and by that means the contact is made which closes the circuit of the electromagnet coils, and both clocks immediately start working. A current considerably less than required for one lamp is sufficient to deflect the needle and to start the clocks, which cease to register when the current is switched off.

The same electromagnets which lift the gravity impulse weight also actuate the recording apparatus. The axle of one clock being hollow allows the axle of the other clock to be brought through it. The hollow axle carries a frame and dial which revolve together, and the other axle carries the wheel which gears into one in the frame, so that if the two axles revolve at exactly the same rate, a pointer fixed to the wheel carried by the frame does not move from its position. When, however, one axle is moving faster than the other, the difference is indicated by a motion of the pointer, and it is evident that by suitable arrangements of counting gear the registration of the difference in the number of revolutions made by the axle in any given time is easily and simply effected. The terminals,

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which are outside the meter, are protected by a cover, which the fitter can remove when connecting up, and after he has replaced it this can also be sealed. In order to protect the pendulum from injury during transport a clamping arrangement is provided, which can be manipulated without removing the cover.

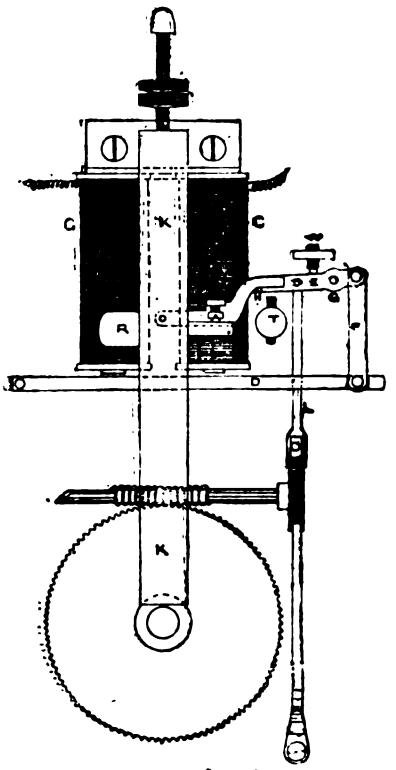

FIG. 2.—Gravity Impulse Gear.

A general view of the meter with the cover removed is given in Fig. 1. The impulse gear is shown in Fig. 2, and Fig. 3 is a sketch of the connections (diagrammatic) of the whole meter. When a current passes through the main coils, consequent upon the

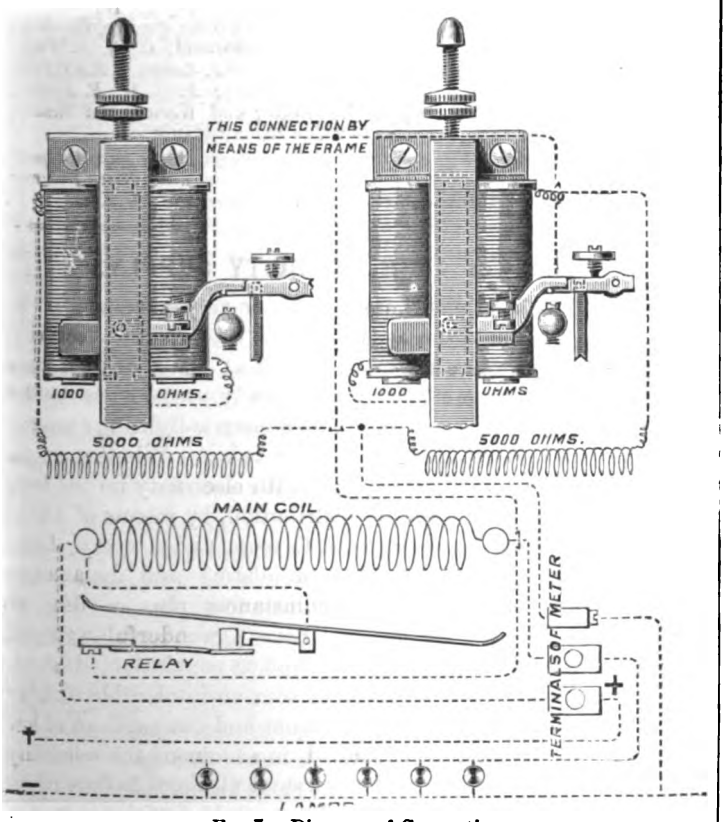

FIG. 3.—Diagram of Connections.

switching on the lamps, the magnetic relay needle is deflected, closing the contacts and putting the contact screws in connection with the shunt circuit for driving the clocks. As both clocks are electrically joined up alike it will only be necessary to follow from one of these screws the course of the current. The pendulum bar K (Fig 2) is insulated from the frame and connected to one end of the coil C, the other end of the coil being connected through a suitable resistance to the return lead, so that the pendulum cross-piece R being in contact with the contact screw S, the coils are energised, the armature D is raised, and the lifting pin H on the end of the lever E is, therefore, depressed. The full weight of the gravity piece then acts upon the bar K through the cross-piece R, starting it into vibration. When the end of the gravity piece strikes the stop T, the bar continuing its forward swing breaks contact between screws S and cross-piece R. The armature D immediately falls, and acting on the lever E through the link G makes the lifting pin H raise the gravity piece, the position to which it is lifted being determined by the stop screw W.

When the bar swings back the circuit is again completed through contact of screw S with cross-piece R, and the cycle of operation is regularly repeated during the time the magnetic relay needle is deflected by the current passing through the main coil. The impulse necessary to maintain the vibrations of the bar K is obtained from the falling of the gravity piece from the definite position of the lifting pin H to that of the stop screw T, and is independent of variation within a wide range of the driving current, due to fluctuations of voltage on the supply mains. Besides lifting the gravity piece, the armature also actuates the pawl or pullet connected with the registering gear, as indicated in the sketch, so that for every complete swing of the pendulum bar a tooth in the wheel is moved forwards, and that swing registered.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, May 5th.

CHEMICAL SOCIETY.

8 p.m. Hofmann Memorial Meeting: Addresses by Lord Playfair, F.R.S., Sir F. A. Abel, F.R.S., and Dr. W. H. Perkin, F.R.S.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Fogs, Clouds, and Lightning," by Shelford Bidwell, F.R.S.

MONDAY, May 8th.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

TUESDAY, May 9th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting: Paper to be further discussed:—"Mining and Ore-Treatment at Broken Hill, New South Wales." By M. B. Jamieson, Assoc. M. Inst. C.E., and John Howell.

WEDNESDAY, May 10th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "The Richmond Lock and Tidal Weir," by J. B. Hilditch.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Students' Meeting. Paper to be read: "The Introduction of Rubble Blocks into Concrete Structures," by J. Wilson Steven, Stud. Inst. C.E.

ROYAL SOCIETY.

9 p.m. Conversazione.

THURSDAY, May 11th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Atmosphere," by Prof. Dewar, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Paper to be read: "On the Prevention of Sparking, Compound Dynamos without Series Coils or Magnets, and Self-Exciting Dynamos and Motors without winding upon Field Magnets," by W. B. Sayers, Assoc. Inst. E.E.

FRIDAY, May 12th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1) "The Drawing of Curves from their Curvature," by C. V. Boys, F.R.S. (2) "The Foundations of Dynamics," by Dr. Oliver Lodge, F.R.S.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Isoperimetrical Problems," by Lord Kelvin, P.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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STEEL-PLATE PORTRAITS

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VARIETY IN ELECTRICITY SUPPLY.

Variety, we are somewhere told, is the very spice of life. If that be so the humdrum aspect of the business of electricity supply must be more apparent than real. We do not here refer so much to multiformity of supply systems as to the widely diverse conditions under which electric-lighting concerns are promoted, started and have their being. Whether or no a certain locality shall be supplied with electricity on the two, three or five wire system of distribution, by means of transformers in every house, or transformers under every street-crossing, or by an array of accumulators and dynamotors depends on topographical circumstances plus a dose of prejudice. Sleepy Hollow may have a wonderful waterfall three miles from the parish church, and its population, although extremely select, may be sprinkled over an intolerable number of acres; yet if fate decree that an out-and-out partisan of low pressure supply shall be consulted, in a moment the reliability of the waterfall is impugned and a stout girdle of feeders is put round the place in less than the proverbial eighty minutes. The high-pressure man does much the same when opportunity offers; the most compact little area imaginable cannot induce him to forego his high volts or his 100 ∽. But, as we have already hinted, we do not feel called upon to investigate the

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extremely thorny law which leads so many electrical engineers to invariably recommend exactly the same specific, be the circumstances of each case what they may. On the contrary, feeling conscious of the existence of a strong "insular prejudice" in favour of English ways of going to work, we hope to modify the same by a glance at one or two peculiarities of the electricity-supply business abroad.

In the first place, across the Channel we have the baneful "concession" method of procedure in full force. A monopoly, more or less complete, is granted for a certain term of years, generally too short to attract any but speculative capitalists into the field, in return for a small sum down and a multitude of petty, indirect municipal pickings—the more numerous, the more petty; the more indirect, the more they commend themselves to the parochial mind—the net *quid pro quo* being a permit to freely squeeze the public. With an annual tax upon every yard of main, an obligation to light the streets for less than, and the public buildings for little more than, cost price and various other burdens of a similar nature, small wonder if the Société Anonyme d'Éclairage Électrique cannot manage to sell the hectowatt-hour at a reasonable price to non-municipal customers. There is a marked tendency amongst our own local authorities to convert the powers conferred upon them by the Electric Lighting Acts into a concession-mongering apparatus. It would be well if the municipal electors would insist upon electric lighting being either thoroughly municipalised, as has been done so successfully in Switzerland, or given a free hand. With the Electric Lighting Acts, the Board of Trade and ordinary municipal foresight, no fear need be entertained that the public may be done out of its rights.

In the Bureau de Contrôle des Installations Électriques, recently formed by the French analogue of our Electrical Trade Section, we have an institution decidedly more worthy of imitation than the custom of concession granting, though, as a matter of fact, there is but a very small chance of it being transplanted. To substitute for Fire Office Rules, Supply Company rules and Institution rules a single code commanding general assent, and for cursory inspections of wiring by miscellaneous gentlemen at odd moments to substitute careful tests at regular intervals by competent and impartial individuals, were a gain alike to wiring contractors and householders. It has been, it is true, our English custom to run our gas-pipes "all anyhow," and to be satisfied with the olfactory test, supplemented on occasions by the crucial experiment of the naked candle flame, but that is scarcely a reason for doing so for all time. In fact, a little more method and precision would be an advantage.

A profound observer of Nature has deduced from a host of disconnected phenomena the great generalisation that it is possible to take a horse to the water, but impossible to make him drink—unless he wants to. Much in the same way, managers of electric-lighting stations on the Continent and in America appear to have discovered that it is easy enough to persuade people to "go in for electric lighting," but that it passes the wit of man to make them pay for it—at any rate, straight off. Thus, at Trent, in the Tyrol, as was recorded in our columns a short time since, the municipal mind in its endeavour to obtain custom and at the same time make the business pay, has hit upon a most ingenious device, which seems worthy of a trial on any not over fertile soil. The low price of 10d. per candle-year, or 6s. 8d. per 8-c.p. lamp per annum is charged, but in order to increase the gross revenue, avoid waste, and save the expense of meters, the Trent authorities reserve to themselves the right of effecting lamp renewals, and charge a tolerably stiff price for the work. In the United States another peculiar custom flourishes, namely, the renewal of the consumers' lamps by the supply companies. At first sight this arrangement would seem to be an instance of the happy self-protective faculty said to be inherent to a civilised society. By all accounts transatlantic central-station managers are not, as a rule, quite so particular about their volts as we are, so that the renewal of lamps by the companies would seem to be a sure specific against over-running; unfortunately, also, the custom almost places a premium on red-hot hairpins. Across the border in Canada a still more free and easy usage has obtained a foothold. From the official report of the proceedings at the second convention of the newly-formed Canadian Electrical Association which was recently held in Toronto, we gather that free-wiring, although regarded with considerable dislike by many Canadian electrical engineers, is deemed by others the only effective way of fighting "a live gas company." So many tales were told at this gathering of the wonderful efficiency of free-wiring in "coaxing people along," that critics were disarmed and confined their criticisms to the custom of charging the work to capital account instead of to working expenses. Opponents were further mollified by the assurance that the free-wiring only included "plain cleat wiring run across the ceilings." As we have frequently pointed out in these columns nothing deters the average London householder from substituting electricity for gas so much as the cost of wiring his house, and the knowledge that his landlord will in most cases reap the benefit of the outlay. What we understood to be an attempt to meet this difficulty was the formation just twelve months ago of the Electrical Fittings Hiring and Maintenance Company with a share capital of over £200,000 and intentions as wordy as its title. So far as we can learn, however, but little has been done by this concern in solving the problem of how to make straight the path that leads to electric lighting. There certainly seems to be a flavour of the small and pushing shopkeeper who throws in a cheap "oleo" with every pound of his 1s. 2d. tea, about this free-wiring, and a device adopted by the Notting Hill Company is, perhaps, more likely to flourish on English soil. This concern has in the case of several extensions of its mains induced those who asked for the extensions to pay the cost of them, the sum advanced for this purpose being repaid in kind, namely, by an equivalent number of Board of Trade units. The consumer gets his light "for nothing" during a period more or less lengthy, and the Company increases its *clientèle* without adding to its capital expenditure. "Notions," transatlantic or continental, may in some instances bear transplanting, and when the tide of lamp-connection begins to slacken and electric-heaters, egg-boilers and flat-irons lose half their attractive force by losing all their novelty, a consideration of foreign practice in these details of the electricity-supply business may not be altogether without benefit.

STEAM PIPES.*

It is difficult from the data published to state precisely the laws of the flow of steam in pipes, except that the loss of pressure at certain velocities is known to be inappreciable. Rankine gives 6,000ft. per minute as the velocity which should not be exceeded, while Seaton gives 8,000. It is probable, however, that steam is not far different to other fluids in the laws as to flow in pipes, in which case, as will be seen by the curves given below, the velocities permissible vary enormously, according to the conditions as to pressure, density, and diameter of the pipe.

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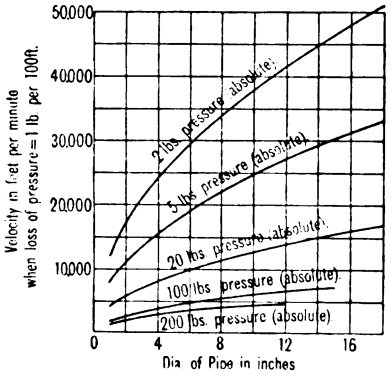
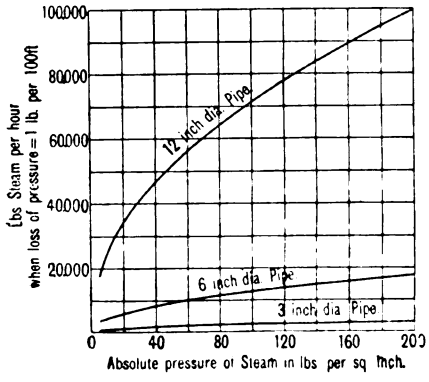
The first curve shows at once how the velocity varies according to the size of pipe for a given loss of pressure due to friction. For example, with a 12in. diameter pipe the velocity may be 41,600ft. per minute, with a loss of 1lb. per 100ft. for exhaust steam at 2lb. pressure absolute, while for the same loss of pressure in a similar size of pipe, but with steam at 200lb., the velocity must not exceed 4,770ft. per minute; or, at 20lb., the velocity under the same conditions must not exceed 14,100ft. per minute. Similarly in a 1in. diameter pipe, the velocity for the same loss of pressure varies from 12,000ft. per minute at 2lb. pressure absolute to 1,380ft. per minute at 200lb.



Curve of Velocity of Steam in Pipes.

The second curve gives at a glance the weight in lbs. of steam per hour, which can be passed through pipes of various sizes under different pressures with a loss of 1lb. per 100ft. Thus, a 6in. diameter pipe under the conditions stated passes 2,018lb. of exhaust steam per hour, at 2lb. absolute pressure; at 100lb. pressure it passes 12,700lb., and at 200lb. pressure 17,640lb. per hour. From this the horse-power can be readily deduced if the steam consumption of the engines is known. Under the last conditions of 200lb. pressure, assuming 15lb. of steam to be required per horse-power hour, a 6in. pipe would serve for 17,640/15 = 1,170 H.P., with only ½ per cent. loss of pressure per 100ft. of steam pipe.



Curve showing Flow of Steam in Pipes.

There is little doubt but that the present system of specifying a certain permissible velocity of steam for all conditions as to size of pipes and pressure is, to say the least, a rough and ready rule-of-thumb method; what should be specified is the maximum fall of pressure. However, as this depends not only upon the loss due to friction, but also upon that due to radiation, a maximum velocity may be specified for each size of pipe; for example, if the working pressure is 100lb. absolute, this might be stated as 6,500ft. per minute for 12in. pipes, 4,500 for 6in., 3,000 for 3in., and 2,000 for 1in. It is to be remembered, however, that, for high pressures, a given fall of pressure between boiler and engine represents a smaller percentage of loss than for low pressures. And the difference of a pound or two of pressure due to friction in the steam pipe is of less consequence than in the exhaust, since the initial pressure is only exerted for a fraction of the stroke, while the back pressure of the exhaust remains throughout the stroke; and since for compound engines this difference is increased by the fact that while the initial steam pressure takes place in the smaller cylinder, the back pressure of the exhaust is exerted in the larger cylinder. In addition there is the loss by radiation which increases with the size of pipe and temperature of the steam, demanding moderation in the size of steam pipe which does not hold in the case of the exhaust pipe. In illustration of this it may be mentioned that in 1,000ft. length of steam pipe 10in. in diameter, at a colliery in Durham, it was found that the heat lost by radiation cost about £100 per annum.

The following may be easily committed to memory *In any pipe the loss of head in a length equal to 33 diameters equals the head theoretically necessary to produce this velocity.*

Approximate Rule for Sizes of Steam Pipes.

Piston speed in ft. per minute.	Area of steam pipe in sq. in.
600	$\frac{1}{10}$ area of piston.
500	$\frac{1}{12}$ "
400	$\frac{1}{15}$ "
300	$\frac{1}{20}$ "
250	$\frac{1}{25}$ "

For small pipes larger areas should be used, particularly if the steam pipe is long.

A TELEPHONIC METER.

At the Electrical Congress at Frankfort in September, 1891, Dr. Strecker, chief inspector of the German Government Telephone Department, read a Paper in which he threw out the idea of measuring the telephonic conversation carried on by each individual subscriber, thus enabling telephone companies to check the misuse by non-subscribers on the one hand, and on the other to make their charges in some degree commensurate with number and length of conversations indulged in. On the basis of this principle the German Government subsequently invited designs for a telephonic meter that would allow the registration of each conversation

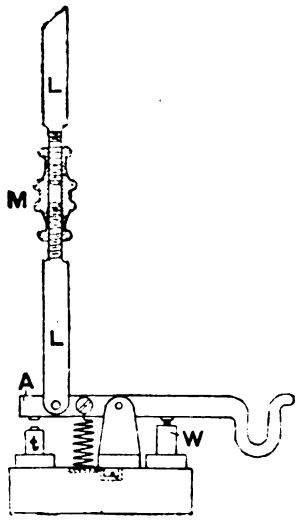


FIG. 1.

from the time of unhooking the receiver to the replacing of the same, and to fulfil the conditions laid down, Messrs. Mix and Genest have devised the contrivance illustrated herewith.

The apparatus consists of a clockwork movement having a starting and stopping arrangement operated by unhooking the receiver, and replacing the same. To the switch A (Fig. 1) a guide rod L is connected, the length of which can be regulated by a nut M. At the free end of L there is an arm F provided with a catch (Fig. 2), which rests on a pin *s* fixed on the pendulum P. The catch is so shaped that the pin *s*, when the pendulum is swinging, lifts the hook when the latter is lowered, and the motion of the pendulum is arrested. When the receiver is unhooked, the switch A is pulled down by the spiral spring, the bell-contact W is broken, and the line-contact *t* is made. This movement lowers the rod L, and the catch is raised to the position indicated by dotted lines, thus releasing the pendulum. It will be seen that the hands of the clock will move as long as the receiver is unhooked, and will be stopped when the receiver is replaced. To switch off the instrument when the clockwork is not wound up and to remind the

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subscriber, there is provided an indicator N (Fig. 2), which is worked by utilising the reduction of tension in the clock spring to limit the movement of the automatic switch. This is done by fixing the catch K, not to a fixed pin, but to a movable lever H (Fig. 2), which moves on the pivot of the barrel itself. The lower end of the lever H moves between two spring buffers, *p* and *p*, of which *p* is provided with the stronger spring. When the clock spring is run down and the pressure taken off the lever H, the lever moves towards *p*. This movement brings a catch R into action, drawing it into a notch E effected in

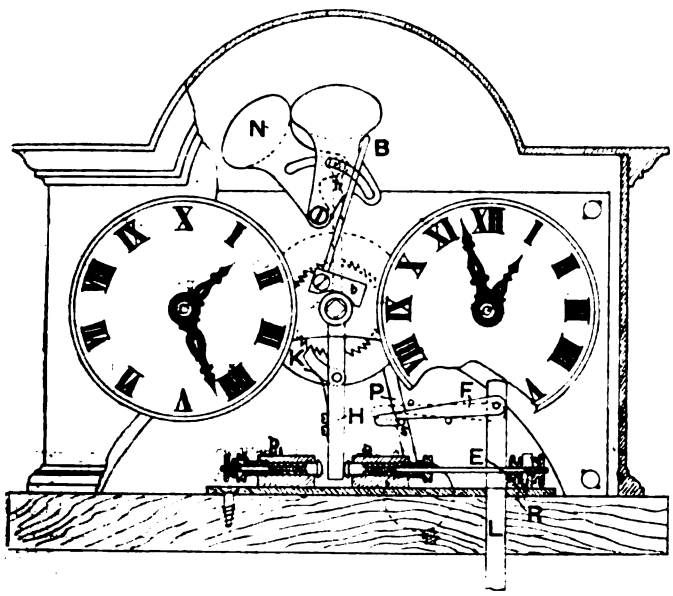

FIG. 2.

the rod L. This locks the rod and the switch. The lever H carries an indicator disc N on its extension H, which, when H moves over, brings the disc into view behind a glazed aperture, giving the warning to wind up the clock. When the clock key is inserted the small lever *b* is pressed sideways, bringing the arm B into action, and replacing the indicator disc.

THE DISTRIBUTION OF POWER BY ALTERNATE-CURRENT MOTORS.

The following is an abstract of the discussion on Mr. Albion T. Snell's Paper, which took place on Thursday evening last week at the Institution of Electrical Engineers. Speakers who have returned their proofs revised have asterisks placed against their names :—

*Mr. SPARKS said he had obtained permission to bring before the meeting two single-phase motors designed by Mr. C. E. L. Brown. The larger one was of the synchronous type, and the smaller one of the non synchronous type. The synchronous motor, although comparatively well known, was not described in Mr. Snell's Paper. This motor had no great torque at starting, so had to be started when the belt was on the loose pulley, and the motor had to be placed in such a position that the brushes made contact each one with a segment. It was very easily started indeed, and he believed everybody who had tried had been able to do it. The field-magnets consisted of four poles, each one with a coil on it, the coils being two in parallel, and supplied the current through a commutator. The armature stampings were perforated, and wires were threaded through these perforations. The electromotive force of the synchronous motor was 92 volts at 40 ∿. To the best of his knowledge there were no installations working at so low a periodicity in this country at the present time. On starting the motor the armature and field-magnets were placed in parallel, and a fixed resistance was put in series in the field, the current being supplied through a choking coil. If the motor was in the proper position it would start when on the loose pulley. It went away directly at a fair speed until it reached a certain definite speed, without any further tendency to increase, when part of the regulating choking coil should be cut out. Then it went faster, and another section of the choking coil must be cut out, until the motor attained a speed of upwards of 90 per cent. of its synchronous speed. The motor then began to make a kind of beat. The field-magnet should now be cut out altogether, and at the same time connected in parallel with a few turns of one armature coil. Directly the resistance was cut out, supposing the motor were running at from 80 to 90 per cent. of its synchronous speed, it as it were galloped up and got into synchronism in a very remarkable manner. As soon as it attained synchronous speed the belt should be transferred from the loose pulley to the fast one. Then the motor could have the load thrown on it suddenly—not only its nominal load, but three times its rated load—without in any way dragging it out of synchronism. The motor ran at 1,200 revolutions at 40 ∿. That motor had been used for several weeks to drive part of the factory in Charterhouse-square, and that type of motor was used up to a size of 10 H.P. The second motor was one which should be of great interest. It was of the non-synchronous type and worked with 120 volts at 40 ∿. Its armature consisted of a number of stampings, and these all had holes through them, and through each hole was a carefully-insulated copper rod. The whole of these were connected up at both ends, so that they really had a number of short-circuited coils. There were no brushes of any kind, and the field-magnet winding was similar to the armature winding of the synchronous motor. There were two sets of coils ; one set was always in use when the motor was in work, and the second was only in use when the motor was starting. In order to start the motor the current was switched straight on to the field-coils, which were connected in parallel. On starting, the second set of coils was connected in series with a condenser of extremely simple construction, consisting of a series of iron stampings separated by wooden blocks, the intervening space being filled up with a 10 per cent. solution of caustic soda. The speed ran up practically to that of synchronism, although it was a non-synchronous motor. The motor when loaded to 1 B.H.P. took 11 amperes at 120 volts, or 1,320 *apparent* watts. When giving during short periods 2 B.H.P., it took 2,760 *apparent* watts. This meant a return in B.H.P., in the case where it was overloaded, of 54 per cent. of the *apparent* watts ; when giving 1 B.H.P., the return was 56 per cent. of the *apparent* watts. With a 10-H.P. motor of this type, weighing between 9cwt. and 10cwt., which was daily working in a sawmill, giving over 15 B.H.P., the commercial efficiency of the normal B.H.P. was between 88 and 90 per cent. of the *real* watts supplied to it, the difference between the real and the apparent watts being 12 per cent., or 80 per cent. of apparent watts appear on the brake. When taking the maximum power from that motor the percentage drop in speed value from that of synchronism was a little over 3 per cent. ; so it was practically a constant speed, although non-synchronous. He would put before them a comparison between a three-phase motor, the particulars of which had been published by Herr Dobrowolski in the *Elektrotechnische Zeitschrift* of March 31st last, and a 1-H.P. single-phase motor tested by Messrs. Brown and Boveri ; if not the actual motor before them, it was a fellow one to it :—

	Three-phase motor.	Single-phase.
Nominal output	1 B.H.P.	1 B.H.P.
Pressure	104 volts.	120 volts.
Current (no load)	7·8 amperes.	6 amperes.
Current (full load)	13·85 amperes.	11 amperes.
Apparent watts	1,440	1,320
Frequency	50	42
Speed (no load)	1,490	1,250
Speed (full load)	1,375	1,210
Per cent. drop of speed	7·22	3·2
Weight of motor	207lb.	141lb.
Temperature rise	40-50°C.	25-30°C.

Motors of that type were running, or shortly would be running, at Baden, Lucerne, Cologne, Dresden, Rome, Ragaz, Chur, Furstenfeld-Bruck, Intra, Grenoble, and other places, and he thought Mr. Brown was to be congratulated on the very remarkable results he had obtained. The special points of the motor were the total absence of the collector-commutator, the ring form of oiling, the ease of mechanical construction up to large sizes, the minimum attention and repairs required, and the great torque obtained at starting. Of course, many had worked in this field, but it was pointed out by Mr. Brown in his letter to *The Electrician* that although many had worked in a similar direction, none had put into practical use any similar motors.

*Mr. SWINBURNE said, like everybody else present, he had been exceedingly interested in the Paper and in the whole subject of alternating motors. He had just received a great surprise from Mr. Sparks, who had described a pair of motors at great length as being quite new to England. This was a surprise, because, curiously enough, the first motor described was made by Mr. Brown, with whom his (Mr. Swinburne's) firm were working, and the English, German, and Swiss patents were all taken out by his firm in his (the speaker's) name. It was naturally a surprise, therefore, to find the motor, as it were, reflected back from Switzerland without his name attached to it, when he thought it was really his invention. The first difficulty which arose in running this synchronising self-starting motor was due to the sparking at the commutator. As early as 1888 he ran a motor of that sort when with Messrs. Crompton. He thought that was probably the first synchronous small motor of that type ever run in this country. It was not a motor one could put into commercial use. Since then he had been working a great deal at the subject, and whilst he had made some that would start, he had also made some that would not. He had not yet, however, made a motor that he would consider himself justified in putting on the market. They must remember that the motor just described was made for a low frequency. It would not work so well when they reached high frequencies. He did not know that it was of much use working out a motor for a frequency of 40 in this country ; they must start with 100, and if they wanted to develop largely they must have it up to 133 for America. There was a great difference between a frequency of 40 and one of 133, as anyone who had experimented largely with motors would know. The chief difficulty with motors had been, not the difficulty of starting, though that, of course, was a serious one, but the difficulty of getting them to run without taking a fairly large current with no load. These motors took 7·8 amperes with no load and 13·85 amperes with full load. It must be remembered that that had to come through the transformer, and it had also to come through the meter, and it would be a difficult thing to place a motor in England that took half-current at no load. He did not think, unless an alternating

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motor would run under nearly the same conditions as a direct-current motor, that it was of much use putting it on the market in this country. They could bring it forward, and get accounts of it in all the various papers, and make a fuss, but he did not think it was a practical solution of the difficulty. With regard to the other motor mentioned by Mr. Sparks, he thought they ought to give credit to whom it was due in that case also, and that motor, he believed, was invented by MM. Hutin and Leblanc. Other people were working on the same thing. Boucherot did some theoretical work. Tesla had patented it more recently, and so had Elihu Thomson; but when they took that motor they would find that the necessity of putting a condenser in series was a troublesome thing. People did not want condensers put in their houses. A condenser also had other disadvantages. He did not think they ever would solve the alternating motor problem until they made a machine which was self-exciting, not excited by the reactions of one of the parts on the other. All those motors, when examined carefully, would be found to be machines which had field-magnets entirely excited by their own armature reactions. That was an evil. He would like to refer to the supposed advantage of the double and triple current He thought there was a great deal too much being said in favour of the double and triple currents. The engineer who ran an alternating station asked the inventor for an alternating-current motor; the inventor brought forward something which he said was an alternating-current motor, but it was at most a sort of quibble, for it was not an alternating-current motor at all in the sense in which the engineer wanted it. The engineer had a circuit with an alternating-current system of distribution, and wanted a motor to run on that; he did not want a motor to run on a totally different circuit which he had not got. But that was what had been offered as an alternating-current motor. He was quite aware that the double and triple current had some advantages over the single current in ease of starting and ease of transmission of small powers from place to place at high pressures. The only advantage with double currents was in starting small motors. If an installation consisted entirely of motors, which would be very curious, then it might pay to use double or triple-current motors; but if the installation consisted of lamps and so on, it would probably be best to transmit a single alternating current over the long distance, and then convert it to direct current, and be done with it, not run a complicated system of which no one could measure the power or anything else, and which there was great difficulty in balancing. He would now come to a question which was half theory and half nomenclature—that was the question which was the armature and which the field-magnets. Ever since this question came up he had been in a minority of one as to which was which. He did not know how the orthodox people explained the matter. He would propose a very simple definition, which agreed with dynamo practice so far as it had gone; that was to say, the field was the part of the machine which had the induction in the iron constant, or in the same direction, and the armature was the part where the alternating current was. It must be remembered that, even in a direct-current machine, the current in the armature was alternating. He would like to point out that the alternating current induced in the field-magnet coil, even if short-circuited, was not an alternating current of the same frequency as the current in what he called the armature. If it was a triple-current machine the frequency was six times that of the armature current, and if it was a double-current machine it was four times. That was rather an important point. There was one other matter he would like to refer to. The power, according to Dr. Hopkinson's equation, was always E times a long expression, which it was not worth while giving, E being the electromotive force of the machine at no load. The machines in question had no excitation whatever, and could, therefore, give no electromotive force at no load, so, according to Dr. Hopkinson's theory of the action of dynamos and motors, neither the "drehstrom" nor any other similar contrivance could work. He, therefore, looked upon this as a standing confutation of the self-induction theory of dynamos.

*Mr. W. M. MORDEY thought, whatever developments might take place in alternate-current power transmission, it would be found that for large powers synchronous motors would have advantages. Mr. Snell said the torque of such a motor must not exceed a certain value, or the machine would stop. He (Mr. Mordey) thought that criticism might be applied to most motors. In the Paper which he (Mr. Mordey) read a few weeks ago he gave some figures showing that the power factor with synchronous motors was very nearly as high as with good closed-circuit transformers. The idle current in the mains, therefore, was not a difficulty. As to the objection that motors must be designed not only with reference to the pressure but also with regard to the frequency of the current, he did not think that was a very great difficulty. Another objection in the Paper to alternate-current synchronous motors was that they had dead points in each period. That was true, but these dead points were very little ones. He thought the fact that steam engines had dead points had not been found an insuperable objection in their case, and he did not see why it should be in the case of synchronous motors. They had been told that in England they had been very backward in adopting "drehstrom" working. He thought, as a matter of fact, English electrical engineers had regarded the two or three-phase motors as merely a make-shift, and they had simply sat still and waited for some one to develop motors that would run with ordinary lighting mains, and he agreed with Mr. Swinburne—and he supposed with most people who had studied the subject—that until motors were produced that could be run on the ordinary alternate-current mains, the same mains as were used for lighting, motors would be very little used except for special cases. The difficulty with regard to frequency was, he thought, a temporary one. In a little while they would have motors that would run at 100 or 133 ∿. This demand for motors on alternate-current mains was one that they were constantly coming across, but they were not coming across it, he was afraid, because of any real demand for motors, but for what one might call electioneering reasons. When people were thinking of putting down lighting plants they were led to say "Oh, but you cannot put down motors on your circuits." It was of very little use to say to them that if they looked around they would not find that it really mattered much. He believed if they had alternate-current motors to-day as good as the direct-current motors which they had on ordinary installations, there would be no great use for them. The whole question was supposed to turn—and Mr. Snell had alluded to that, although not very pointedly—on the question of periodicity, and he wanted to say a few words about it, as there was a disposition to go down to 40 or 50 ∿, instead of 80, 90, 100, or 130 ∿. He was reminded of a remark made by Mr. Brush a little while ago to an eminent member of the Institution, who was explaining to him the advantages of using 20 or 25 ∿ for some scheme that he was considering. Mr. Brush said, "Oh yes, that's right! Get a little bit lower, and you will have a good honest direct current." He (Mr. Mordey) really thought that when they got down to 20, 30, or even 40 ∿, they might just as well have a good, honest direct current, because the disadvantages of alternating currents at low periods were so great that very little could be said for them in comparison with direct-current working. The real reason, or one of the principal reasons, why 40 ∿ periods had been so largely used on the Continent might be, he believed, traced to the difficulty of designing machines of certain types to work at a greater rate. The Ganz machines were, perhaps, the most largely used on the Continent, and he believed they were worked at 40 ∿ simply because the machines had a lot of iron in them, and there were electrical and structural difficulties if any attempt were made to use them at higher rates. Now, in alternate-current distribution the key to commercial economy was to be found in the transformer. To make a transformer equally good and equally efficient at 40 or 50 ∿ as at 100 ∿ was very difficult. The transformers were not only costly, but they were wasteful. It was not, as he had been told, a question of design. He had been told that he must not use a 100-period transformer at 40 ∿, or a 40-period transformer at 100 ∿, but must design a transformer properly, put more iron in in the one case, and so on. Well, he had taken a 40-period transformer made by most experienced makers, and he had run it at 100 ∿, and, of course, he had found that, although this had been designed specially for working at 40 ∿, it was very much more efficient working at 100 ∿ than at 40. Then he had taken a 100-period transformer and run it on 40-period mains and burnt it up. So he thought that showed there was no basis of truth in the argument that they could design transformers equally well for any period. He thought if they took any ordinary transformer and considered the magnetising-current curve, they would find that from 40 to 80 or 100 ∿ they would decrease the current very much, and not only did they increase the current, but the power factor was not improved as they went down in periodicity. The motor difficulty was merely a temporary one. Mr. Sparks had shown it that night half solved; if they waited a little while they would see it solved altogether. How important efficiency was was not properly realised. It was thought a few watts more or less did not matter very much. But if they reckoned out the power spent in magnetising transformers, and took the very lowest estimate—let them take, if they liked, one penny per horse-power per hour—they would find that each watt continuously expended cost a shilling a year, and there was no station in this country that could produce a watt continuously for a shilling a year in that way. They might take it that two or three shillings a year was thrown away on every watt wasted, and if they worked at 40 ∿ they threw away more money, and spent more money on their transformers to start with. And really, what applied to transformers would, he believed, be found to apply to motors.

*Mr. KOLLE asked to be allowed to supplement Mr. Sparks' remarks. Mr. Brown had already working at Chur, in Switzerland, a 3-H.P. single-phase self-starting non-synchronous motor working at 70 ∿, and they had also at the Ferranti works at the present time a single-phase self-starting synchronous motor which worked on the London Electric Supply Corporation circuits of 85 ∿. A further advantage of the Brown motor was the small clearance between the armature and field magnets.

*Prof. AYRTON said Mr. Snell's Paper raised a very interesting point indeed with reference to the use of motors on alternate-current circuits. As far as he knew, Prof. Forbes was the first to publish the idea of constructing a motor in which they commutated the current through the field, producing, of course, sparking at first until they got up the right speed, when there was practically a pulsating direct current through the field. That must have been in 1882 or 1883. With reference to the question of field and armature, the suggestion which Mr. Swinburne had proposed was a suggestion which Prof. Perry and he had made in their much abused paper on motors at about the same early date, 1881 or 1882. There they said their motor was a motor with a stationary armature and a rotating field, and they said distinctly that by field they meant the part of a machine which had a direct current round it, whether it rotated or not, and by armature the part which had the current alternating in its coils, whether it was stationary or not. But the definition was not quite so simple when they came to a "drehstrom" motor, because if there they called the part of the motor in which the current alternated the armature, then, as in that case both parts of the current alternated, there would be two armatures and no field-magnet. The only way to improve the definition in a machine with a varying current in each part was to call the field the part in which it varied the least, and the armature the part in which it varied the most. In advising a town a little while ago to use alternate currents, he told them the motor question was not worth considering, and that if anybody wanted to use an alternate-current motor it would pay the company to supply power at a penny or twopence per unit cheaper to them to compensate for any want of efficiency in the alternate-current motor. The advantages of using transformers for distribution of electric-lighting current were so great in a scattered town that the small disadvantage of the inefficiency of alternate-current motors was not really worth considering. Mr. Kapp at the last meeting had pointed out one reason, viz., the armature reaction, why the

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theoretical variations in the field of a "drehstrom" motor were so great. Another cause was that the calculations applied merely to the variation in the exciting *current*. When iron was magnetised the induction did not vary nearly as much as the current, and thus when there was a variation of 14 and 20 per cent. in the exciting current, that did not correspond to anything like the same amount of variation in the magnetism, which was, of course, the important thing. In speaking of the series or open circuit, Mr. Snell spoke of the potential difference at the terminals of the coil lagging 30deg. behind the potential difference between the mains. That was a mistake. It should be that the potential difference at the terminals of a coil with series winding was 30deg. in advance of the potential difference between the mains. It was not true, as Mr. Snell seemed to infer, that the output for a given weight of material was less in the three-phase system, assuming no self-induction, than with the two-phase. This was pointed out some years ago by Dobrowolski. With the three-phase system of transmission they had three wires on the poles, each wire carrying a certain maximum current, the insulation being such as to allow a certain maximum potential difference between mains. They increased the cost of the wires by 50 per cent., but they increased the output by 73 per cent. over that of two wires with the single-phase current. The speaker then proceeded to examine the Paper in detail, pointing out certain errors on the formulæ, and concluded by remarking that the Paper contained a number of direct results, and Mr. Snell had endeavoured to put the well-known theoretical consideration about "drehstrom" motors before them in a simple fashion, and, therefore, he thought they ought to thank him for his contribution to the subject.

Mr. SNELL, in replying, said the subject bristled with difficulties, and he was afraid he could not do justice to the various speakers who had done him the honour of criticising his Paper by immediate reply, and he must take time to think out some of the questions they had raised, so as to make a suitable answer in the proceedings of the Institution. But there were one or two points he should like to refer to at once. Mr. Sparks had put before them a very interesting motor. He did not agree with Mr. Sparks that so much credit was due to Mr. Brown. It was, after all, as Mr. Swinburne had said, nothing but the development of Elihu Thomson's motor. He was speaking now about the synchronous motor. With regard to the non-synchronous motor, that had undoubtedly advanced the subject very materially; but, as he had said in his concluding sentence, the problem of alternate-current motors suitable for running on ordinary electric-lighting mains was not satisfactorily solved. He thought the majority of speakers that evening bore him out on that point. At the time he wrote the Paper he was thinking very much about motors for use in coal pits, and there the question was not so much a motor which would work with high efficiency as a motor which would work without sparking, and the little motor shown on the table realised that condition. If the efficiency of that motor was only 60 per cent. it would do for a good many purposes in a coal pit, and if a larger motor could be built with an efficiency of 70 to 80 per cent. they might be said to have advanced the question of the application of power to mining work very materially. Lighting in the coal pit was of secondary importance altogether, and if the light fluctuated a little it would be of no consequence. He would like to say a few words about the definition of field and armature. He had taken the definition which he believed was the Continental one; that was, he called the armature that part which had the currents induced in it, and he called that part the field which had the current supplied to it. That being the case, he called the stationary part of Mr. Brown's motor the field. He called the part that revolved the armature, because it had currents induced in it by virtue of those currents. But, undoubtedly, from purely theoretical considerations, the suggestion that Mr. Swinburne had made, amended by the further improvements of Prof. Ayrton, was well worthy of consideration, and probably those terms would hold in future; but for his Paper, and for the present, as he had clearly defined the meaning of the terms he had used, he thought there was no need for confusion.

The CHAIRMAN (Mr. Alexander Siemens), in according the thanks of the Institution to Mr. Snell, said he could not help emphasising one point which had been brought out, and that was that the English engineers should not be too much blamed for holding out in this question of alternating currents. They were, after all, a body of practical people who had to apply science to everyday life, and the practical question which to a great extent governed what they were to do and what they were to investigate was the eternal question of £. s. d. His firm had worked a great deal upon rotary motors in Berlin, but they had not done so much here, because it was obviously unnecessary to go into a separate set of experiments while they had the experience of Berlin at their disposal. In every case where they had to work out problems for transmitting power to a distance they had given the exact problem to their Berlin house and had asked them to work it out, and up till now they had not had one instance in which they could not carry out such a problem just as well either by direct currents or by the ordinary alternating-current machines as they could have done by the rotary currents.

PHYSICAL SOCIETY.

At the meeting on April 28, 1893, Prof. W. E. Ayrton, F.R.S., Past-President, in the chair, Mr. E. C. RIMINGTON read a Paper, on

"Luminous Discharges in Electrodeless Vacuum Tubes."

The luminous rings produced in exhausted bulbs and tubes by discharging Leyden jars through coils surrounding them, had, he said, been attributed by Mr. Tesla (*Electrical Engineer* of New York, July 1, 1891) to the electrostatic action of the surrounding wire rather than to the rapidly varying magnetic induction through the rarefied gas. The present Paper describes several experiments bearing on this point, which lead the author to conclude that varying magnetic induction is the chief cause of the luminous rings. They also show that a superposed electrostatic field greatly assists the production of the luminosity. Most of the experiments described were performed before the meeting, some of the effects being particularly brilliant. In one experiment an exhausted bulb (Fig. 1) was placed within a coil *a b*, connecting the outside coatings of the Leyden jars A and B, and placed between two metal plates C and D, which could be connected at will with the outside of either jar. The spark gap S between the inner coatings was then arranged so that no luminosity was seen in the bulb. On connecting one or both the metal plates with the jars by means of the wires *e f* in such a way as to increase the electrostatic field through the

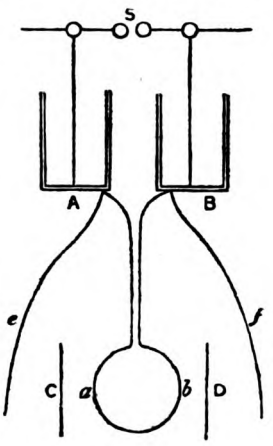

FIG. 1.

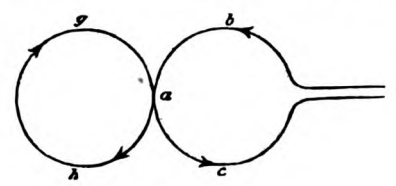

FIG. 2.

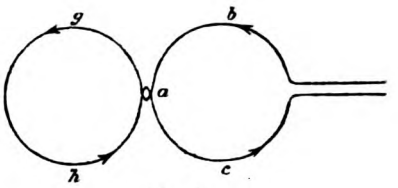

FIG. 3.

bulb, bright rings immediately appeared. An electrostatic field produced by a small induction coil connected to a piece of tinfoil on the bulb caused the rings to form at irregular intervals when the discharge of the jars and coil happened to be properly timed. In another experiment two loops of wire (Figs. 2 and 3) in series were used, and when put on the bulb in such a way as to produce a large magnetic effect but small electrostatic field, bright rings appeared; but if the magnetic effects of the coils opposed each other whilst the electrostatic field was increased, no rings were seen. Putting the wire (Fig. 3) on a bulb, a discharge was obtained (Fig. 4) like the sector of an orange.

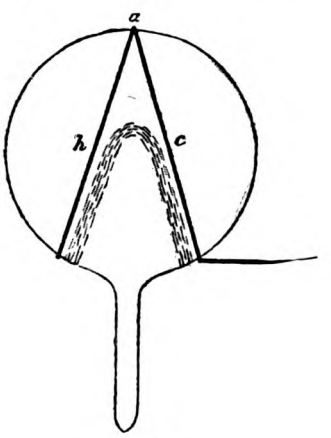

FIG. 4.

The subject is treated mathematically at some length in the Paper, the times at which the maximum values of the current, the potential difference between the outsides of the jars and the rate of change of current occur, as well as the values of their successive maxima, being determined. The influence of "Size of Jars" is next considered and the time-integral of rate of change of current, on which the effect on the eye depends, expressed as a geometrical series. Taking an approximation, the author shows that the time-integral is roughly proportional to the fourth root of the capacity. Large jars are, therefore, theoretically only slightly better than small ones, and this agrees with observation.

On the subject of "Apparently unclosed discharges," such as are seen when discharges pass through a coarse spiral wound on an exhausted tube, the author said he had observed that the discharges were really closed, but the return part much diffused and of feeble intensity. Experiments were exhibited showing that under some circumstances an exhausted bulb acted like a closed metallic circuit, whilst under other conditions dissimilar effects

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were produced. Another experiment was shown in which a faint luminous ring, produced by a single turn of insulated wire round a bulb, was apparently repelled on touching the wire with the finger.

The author also showed that fan-shaped luminosities could be produced by rotating an exhausted tube in the electrostatic field produced by a charged ebonite or glass rod.

Dr. SUMPNER, speaking of the apparently unclosed discharges, pointed out that they might be closed through the wire forming the primary circuit, in the same way as a coil of a transformer might be arranged to act partly as primary and partly as secondary.

Prof. S. P. THOMPSON thought an electrostatic field would aid a discharge even if its direction was not the same as the E.M.F. due to varying magnetic induction. Planté had found that vacuum tubes through which 800 cells were insufficient to produce a discharge immediately allowed a discharge to pass when a rubbed ebonite rod was brought within about 10 feet distance. This effect was found to be independent of the direction of the disturbing field. Analogous effects had also been observed by Prof. Schuster, and described in his Bakerian Lecture.

Mr. E. W. SMITH regarded the stresses set up in the medium as cumulative, a very slight cause acting on a substance already strained nearly breaking point being sufficient to cause breakdown.

Mr. BLAKESLEY inquired if the effects were the same if the induction

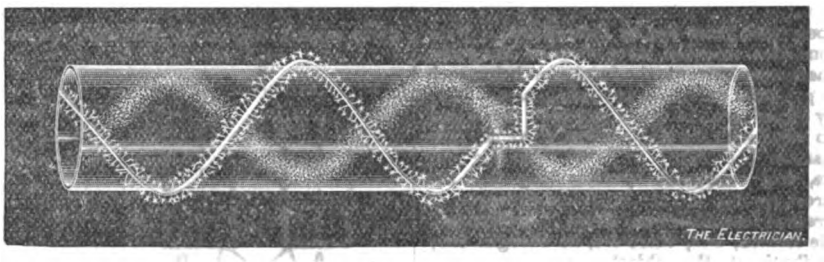

FIG. 5.

Mr. A. P. TROTTER, after referring to Dr. Bottomley's researches, said it was important in discussing such experiments to distinguish between electrostatic and electromagnetic effects. In Mr. Campbell Swinton's experiments the luminosity always appeared to get as far away from the wire as possible, and to be at right angles to it, whereas in Mr. Rimington's the luminous portions were close to the wire. With a view to puzzling the discharge in Mr. Swinton's tubes he had made a right-angled bend in the spiral surrounding the tube, the result of which (Fig. 5) was to make the luminosity discontinuous, one end of the break being bifurcated. In all Mr. Swinton's experiments brilliant brush discharges surrounded the wire.

coil, used in one of the experiments, was replaced by an electric machine, and whether the direction of the field so produced influenced the result.

Mr. W. R. PIDGEON said closed circuits were necessary, and he had found it very difficult to produce discharge in tubes unless the ends of the primary wire were brought together.

In his reply, Mr. RIMINGTON said each turn of the luminous spiral formed a complete circuit of itself. The phenomena observed by Mr. Campbell Swinton were quite different to those he had shown, and due to different causes; Mr. Swinton's spirals were reversed, and were due to phosphoresence of the glass.

LEGAL INTELLIGENCE.

Elgood v. General Electric Power and Traction Company (Limited).

An action to recover damages for injuries caused by the alleged negligence of a person in the defendants' employ while navigating one of their electric launches on the Thames was tried on Friday and Saturday last, in the High Court, before Mr. Justice Grantham and a common jury.

Mr. Lockwood, Q.C., and Mr. G. Elliott were counsel for the plaintiff; Mr. Waddy, Q.C., and Mr. Brunner for the defendants.

Mr. LOCKWOOD, Q.C., opened the plaintiff's case, and called

Mr. ERNEST CRAWSHAW ELGOOD, the plaintiff, who said he was a member of the Bar and a member of Lloyd's. On July 6, 1892, he was with a party of friends at the Molesey Regatta, and they were turning to go in to the Castle Inn landing-stage when he heard a cry, "Look ahead, launch!" The launch struck their punt on the port side, and rose over the gunwale. The water came in rapidly, and the punt turned turtle and threw its occupants into the water. He held his wife up until assistance came from the shore. She was very ill all night. There were no lights on the punt. The Board of Trade required one man only to be on board the launch. The man in charge of the launch stood in the bow.

Mr. ORLEBAR said he was the owner of the punt. He saw the launch coming round when she was forty or fifty yards away. Seeing there was a possibility of a collision he shouted, "Look ahead, launch!" but no notice was taken, and the motive power was running when she struck the punt. The launch did not alter her course or speed. There was no fixed rule in regard to river traffic, but a launch should give way to a boat.

Mr. WADDY, for the defence, said the launch was going slowly, in consequence of the motive power being nearly exhausted. One man was amply sufficient to navigate the launch. A good look-out was being kept. It was a dark night, and the punt was in the dark shade under the bridge without a light. The whole fault was Mr. Orlebar's.

HERBERT WILSON said he entered the service of the defendants at Easter last year, and was constantly in charge of one of their electric launches. On the night of the accident he was in charge of the launch "Theta." He carried lights. As he approached Hampton he was going from two to three miles an hour, going at half-speed. It was a dark night. He was standing right forward in the launch. The switches and wheel were forward, and all within his reach. On approaching the bridge a black object shot out from the bridge in the way of the launch. He reversed, but too late to avoid collision. One of the gentlemen caught hold of the bow of the launch, which was going astern, and capsized the punt. Before he could put the lever to reverse he had to turn a lever to cut off the current. In order to reverse, it required three actions—first, to cut off the supply, next to reverse, then to put on the supply.

ROBERT TAGG, boat proprietor, Molesey, said on the night of the accident he was on the landing-stage. He did not see the launch before the collision. He did not think it proper watermanship for a punt without a light to come through the third arch and cross to the second.

WILLIAM PEARCE, the defendants' foreman, said defendants had eight boats of the "Theta" class, which were under the care of one man. One man was quite sufficient to manage a launch of that class.

Mr. Justice GRANTHAM, in summing up, said the question was whether the defendants' servant was negligent, and, if so, were the plaintiffs also negligent. If there was negligence on the part of the defendants and not on the part of the plaintiffs, then the defendants would be liable. There was no doubt that the punt could not be seen at any distance. They ran considerable risk going about on the river at night without lights. Had the defendant time to pull up or do something after he heard the shouting? There was no negligence on the part of the defendants' man in not seeing the punt before the shouting, because it was a low dark object in the shade of the bridge. If the defendants' man could have pulled up in the time after he heard the shout, and did not, then the defendants would be liable.

The jury found a verdict in favour of the defendants.

Fowler, Lancaster, and Co. (Limited).

In the Chancery Division on Wednesday last week the case of Fowler, Lancaster, and Co. (Limited), came before Justice Vaughan Williams. The petitioners were creditors for a debt of £159, due on a dishonoured bill, and they petitioned for an order for compulsorily winding-up, notwithstanding that voluntary liquidation had been resolved upon.

Mr. Hart appeared in support of the petition; Mr. Farwell, Q.C., appeared for the Company and opposed the petition.

Mr. HART said the Company had carried on business at the Albert Works, Graham-street, Birmingham. The ground of the petition was insolvency and failure of the Company. The failure was attributed to lack of sufficient capital to work the business economically, general depression in trade, and the crisis through which the electrical trades had lately passed. Fowler, Lancaster, and Co. was incorporated in 1890, with a nominal capital of £22,000, of which £17,820 was subscribed. The Company was now in a state of hopeless insolvency, with unsecured debts amounting to £6,500 and debentures £7,000. Under these circumstances the unsecured creditors thought their interests would not be sufficiently protected by voluntary liquidation conducted by the nominee of the debenture and shareholders, and asked the Court for a compulsory order.

The petition was ultimately adjourned for evidence as to the formation and working of the Company.

Vestry of St. Margaret and St. John v. Queen Anne and Garden Mansions (Limited).

On Thursday last this case came before Justices Day and Bruce in the Queen's Bench Division. It was an appeal by way of special case from the decision of Mr. Sheil, Metropolitan Police magistrate, who had decided that the cinders and ashes produced by the Company which supplied Queen Anne's Mansions with the electric light, &c., were not trade refuse.

Mr. Finlay, Q.C., and Mr. Percy Gye appeared for the Vestry in support of the appeal; while Mr. Boyle opposed it.

Mr. FINLAY, in support of the appeal, said the Company which produced the refuse was called the Queen Anne's Mansions Lighting and Heat-

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ing Company (Limited), and held a lease for a term of eighty years of a piece of ground under the courtyard of Queen Anne's Mansions. The Company supplied electric light to the mansions, and had power to supply it to any other building. Vestries were bound to remove house refuse, but in the case of trade refuse they were entitled to be paid for removing it. The question raised by the case was whether the cinders and ashes produced by the Company in supplying the mansions with electric light were refuse produced in the course of a trade. The magistrate was of opinion that they were not, but he (the learned counsel) submitted that the magistrate was wrong, and that his decision ought to be reversed.

Mr. BOYLE, in opposing the appeal, said the Company was formed solely for the purpose of supplying hot water, hot air, and electric light to Queen Anne's Mansions, and, therefore, could not be regarded as a company carrying on a trade. Therefore, the cinders and ashes produced on the premises were not trade refuse.

Mr. Justice DAY said in his opinion the cinders, &c., were essentially trade refuse, and, therefore, the appeal would be allowed.

Mr. Justice BRUCE concurred.

Brush Electrical Engineering Company (Limited) v. Sage and Co.

This case was in the list to be heard by Mr. Justice Day in the Queen's Bench Division on Tuesday. When the case came on, counsel for the plaintiffs stated that it had come to their knowledge that the defendants were bankrupt, and upon that account he would withdraw the plaintiffs' claim.

CORRESPONDENCE.

SINGLE-PHASE ALTERNATING-CURRENT MOTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I do not think that the letter of Mr. Brown in your issue of March 31, 1893, affects my contention that motors, working on a principle, the discovery of which he had stated was the result of his own observations, were known in the art. I called attention in my letter, to which he refers, to my patent 407,844 in support of my assertion. I also stated that I had experimented with various forms of these motors, and I will now be more explicit in relation to them. One of my first motors had the relation of its field coils and armature as 1 : 3—that is to say, the field circuit through which alternating currents were passed, being single, there were three armature circuits closed when running. Other motors made in 1889 have numerous armature circuits, in relation to the field coils. I tried smooth winding, but always found the projection armatures more effective. None of these motors were synchronising motors, as Mr. Brown seems to think, but behaved just as he has stated in the words "only when running light will the speed approach synchronism. When loaded the speed of the rotating park sinks so far below synchronism that the current produced by this difference of speed gives the necessary torque. The extent of this drop depends on the form of the rotating part, &c.," when referring to his modification.

In my patent the statement is made that "many arrangements of coils and cores may be used." Mr. Brown in his last letter says, referring to the work of Mr. Tesla and myself, "but I would point out that certain points in their machines were inherently defective, and that it was only by remedying these that I have been able to produce a practical single-phase motor." In other words, as I understand it, Mr. Brown in 1892 has remedied defects of motors the principles of which he now admits have been known a long time since. If this be so then my original contention remains. Further, I submit that the remedies applied are just those which have been applied to all classes of electrical machinery in the past few years—a more intelligent use of iron projections than formerly. I have the greatest admiration for the skill and engineering ability shown by Mr. Brown in his work, but must insist on the identity of principle of his motor and those which preceded it.

In the statement at the close of his letter regarding the high frequencies in vogue in America, and "that there was nothing to prevent the adoption of a lower frequency in the then early stages, &c.," he assumes a familiarity with American conditions in 1888-1889. The statements he makes show conclusively that he does not, and did not, possess this familiarity. The great demand for an alternating single-phase motor in 1888-1889, and even now, is for one which will go upon the existing lines distributing alternating-currents of 125 to 130 frequency. The actual fact was that in America up to 1889 these frequencies had been largely introduced, and the desire for uniformity has continued the practice even to the present, when we know much better than we did then what the practical differences in the use of high or low frequencies are. There is now, indeed, a tendency in America to come down to lower frequencies, but it is as yet little more than a tendency. Let us suppose that we had in our possession on sale a few hundred of Mr. Brown's modification of the single-phase motor here in America, and of all sizes and capacities, and then put the question, could we sell them to run on existing systems practically, economically, and satisfactorily? and the bearing of the high-frequency question, even to-day, in spite of tendencies, will be emphasised in the answer.—Yours, &c.,

ELIHU THOMSON.

GAS POWER FOR ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should like, through the medium of your columns, to call the attention of gas-engine manufacturers and others interested in gas power for electric lighting to certain points which appear to be neglected. I am a believer in the future of gas engines for central station electric lighting, the gas to be produced by Dowson's generator, or some similar apparatus.

Without expressing any opinion on the merits of the various systems of electrical distribution, I may safely say that there are many places, especially the smaller provincial towns, where the alternating system is the only one that can be used with success. It is also well recognised that the parallel running of alternators is a point of the greatest importance.

As consulting engineer to two central stations about to be put down, I am endeavouring to procure a type of gas engine which will be steady enough to work alternators in "parallel," even at light loads.

For this purpose the single-cylinder, single-acting type of engine, working on the Otto cycle, governed by cutting-out explosions, is manifestly unsuitable, and gas-engine manufacturers who are simply relying on high speeds and heavy fly-wheels are clearly not on the right road to success. It is possible in central stations of small size to arrange for the mechanical coupling of the alternators, but this would probably be found impracticable on a large scale. For working alternators, even of the best type, in parallel it is certainly necessary that each engine should have at least two impulses per revolution.

Totally regardless of this, most of the chief manufacturers advertise their single-cylinder, single-acting engines as perfect for dynamo driving, thereby utterly ignoring that system of electrical distribution which is more used than any other, and which these so-called perfect engines are totally incapable of driving successfully. There is but little difficulty with direct-current dynamos helped by accumulators, but gas-engine manufacturers are very blind to their own interests if they continue to ignore alternating-current working, as they are at present doing.

Even for direct currents, high speeds and heavy fly-wheels are a disadvantage, for they mean excessive wear and tear and liability to break-down, which should be avoided if possible. Could the difficulty of stuffing boxes be overcome (and one firm appears to have succeeded in this), the adding of an extra single-acting cylinder tandem fashion would give one impulse per revolution, and would double the power of an engine without increasing the size of its connecting rod, main bearings and other parts in front of the cylinders. Two such tandem engines coupled would give two impulses per revolution. A twin-cylinder, double-acting engine gives two impulses per revolution, as would also a tandem engine with double-acting cylinders. This latter type would have great advantages. The connecting rod, main bearings, &c., need not be larger than those for an ordinary engine one quarter the size, so the engine should be a cheap one in capital cost, and should have a high mechanical efficiency.

This difficulty of stuffing boxes seems to me capable of solution by passing cooling water through the piston rod. I can imagine several ways in which this could be arranged. It is certainly in the direction of quadrupling the number of impulses that manufacturers should work, if they wish their

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engines ever to be used in alternating-current central stations. Not only this, but governing down to at least half load must be performed by varying the power of explosions, and not by cutting them out altogether.

Trusting that you will kindly insert the above,—Yours, &c.,

J. A. McMULLEN, M.I.E.E.

London, N.W., April 26, 1893.

CONCENTRIC WIRING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the present letter I propose to deal with the objections raised by you to some points connected with the use of grooved boarding, or casing (if the term be preferred), that were raised in my article which was printed in *The Electrician* of the 7th inst.

In the first place I would like to enter a protest against the assumption, which I believe is contained in your Note, that articles in technical journals should only contain what does not happen to be common knowledge to those few engineers who stand in the front rank of their profession. The great majority of writers on technical subjects spoil their work and seriously detract from its usefulness, in some cases even rendering their writings absolutely worthless to all except a favoured few, because they have before them when writing not those to whom their knowledge and experience would be of immense value, those who have not the opportunity of acquiring it for themselves, but their own *confrères*, their own rivals—those who know as much about the matter as they do themselves.

Technical literature, if it is to fulfil its proper function, and whether it be in the form of books, of articles in technical journals, or of Papers read before scientific societies should be written primarily for those who do not know, not for those who do know the subject well. Of what use is technical literature unless this rule is observed.

In the present case you very truly remark that the best firms do not use soft wood, &c. That is to say, you mean, if I understand you aright, that those who understand their work thoroughly do not commit certain faults that were condemned in my article. But the article was not written for the best firms. The writer would not think of attempting to teach those who understand the subject quite as well as he does himself. It was written for those who do not understand, and who do bad work in consequence. Electrical engineers who do understand their work may chafe as much as they please against orders going to men who do not understand their work; but the orders will go there all the same, and the major portion of them, simply because the prices asked will always be less. In the matter under discussion, too, it is well known that as soon as the electric-light mains are laid in a town every ironmonger, bell-hanger, plumber, and general jobber dubs himself an electrical engineer, lays himself out to take orders and, having plenty of time, often not too scrupulous a tongue, and putting the figure low, he gets them.

Now, the question is, What is the best course to adopt with regard to these? They are only birds of passage, though they rob old-standing businesses of a good deal of work. It is useless to warn intending employers. They rarely see the technical journals, and if *bonâ fide* contractors do go out of their way to warn them, their action is looked upon as due to trade jealousy, because the prices are lower. More than that, the ordinary buyer will often think that the *bonâ fide* contractor is making a deliberate attempt to swindle him. In any case, it is bad form at best to insinuate that other people's work is bad, and it is not a wise course to pursue.

As the irregular contractor cannot be kept out, is it not the next best thing to give him an opportunity of knowing something of the work he is undertaking, so that there may be fewer chances of his doing his work badly?

It is not much that can be done, even by the ablest writer, in this direction; but every little that can be done is so much gain. Bad as it is for the irregular contractor to get work away from those who have spent time and money in mastering their business, the evil is very small compared to the deterrent result produced by bad work. Next to securing a contract himself, the writer always likes to see it go into the hands of a firm that will carry it out well. There are also another class of readers to whom information of the kind contained in the writer's article should be of service, viz., those who actually have the execution of the work. Young engineers and workmen often have ideas of their own which they are apt to act upon, and which are sometimes not in accordance with the wishes of their employers. Now, as to the casing itself. Whether hard or soft wood is used moisture will collect in the pores unless these are previously filled with some other substance; and of possible substances shellac is the best, except in a few special cases. Paint or pinotting should not be used, because they will not thoroughly fill up the pores, and because they contain metallic bases which will be deposited by the leakage current.

It may seem to strain matters to say that hard woods will hold moisture; but when we remember the trouble that arose in the early days of the Leclanché battery, from the salts creeping up the pores of the carbon plate and attacking the lead cap, until the pores of the tops of the plates were filled with paraffin wax before being capped, we should not be surprised.

Next, no substance that is used for the insulation of electric light cables will withstand the continuous presence of moisture. Gutta-percha stands wet better than any other substance, but gutta-percha has long been tabooed for electric lighting cables, and even gutta-percha gives way if there is much moisture present and the insulator is thin. Of course, the thicker the coating of indiarubber, the longer it will resist the action of moisture; but the question is only one of time after all, and it is less expensive to exclude the moisture than to increase the thickness of the rubber covering.

It need hardly be mentioned, too, that even in the very best-built houses moisture is very often present during wet seasons; while in the modern villa, which will form a large portion of the work of the future of this kind, damp is too often always *en évidence*.

Now, my point is that unless the pores of the wood-casing are filled up with an insulating substance, the wood acts like a sponge, collecting moisture wherever it is present and presenting it to the insulating covering of the wire proper in the manner calculated to do the greatest amount of damage. It should not be forgotten, also, that the leakage current aids the action of the moisture very materially and adds to the trouble.

You ask, if moisture is to be excluded why not go back to the impregnated jute covering, and you also ask, surely wood-casing is only intended for mechanical protection? Both of these queries should be answered in the affirmative. Where jute covering is permissible as an additional protection, outside of the regular insulation, the writer prefers it very much to grooved boarding, and his experience is that if plenty of jute be used a very much better result is obtained than is possible with wood-casing.

But in many cases jute is not permissible. In domestic work, for instance, it cannot be used; and there may also be places where it is more convenient to use casing than a covering of jute. In either case my view is that the moisture should be prevented from collecting.

Your objections with reference to bad joints and the arrangement of joints will be met by the remarks that have been given above. It is not those who practice the best methods for which the article was written, but those who do not, and whose failure to do so may possibly have been due to want of knowledge or experience.

The writer will make a few remarks in reply to Mr. Sam Mavor's letter in the current number of *The Electrician*, and will hope to deal with the question of "earthing" electric light circuits in another article.

My view is that cable makers cannot put either lead or armour outside of the insulation of the cable without danger of damaging the latter. It does not follow that the cable breaks down at once. Often no known test will disclose the incipient fault; but in course of time the leakage current finds out places where the insulation has been strained, and gradually breaks it down, a spark passing across and destroying a considerable length of the cable.

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The cable I mentioned, which caused a fire on board ship, formed part of an electric-lighting system in which the body of the ship formed the return circuit, the outer armour of the cable being in contact with it everywhere. Mr. Mavor also asks whether my advice to make all connections large and in sight is not a confession of weakness, and he asks further, why not close the whole thing in, as suggested in Mr. Mavor's first communication. My reply is that in my experience you cannot safely close the whole thing in. Moisture will find its way through the finest capillary space, and, as is well known, capillary attraction defies gravity. If you can weld the adjacent portions of metal together, beneath which the joint is enclosed, you can keep out moisture, but in welding you will destroy the insulation.—Yours, &c., SYDNEY F. WALKER.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The Corporation of Clonmel, Ireland, invite tenders for lighting the streets of the town and the Town Hall by electricity. Street lighting areas represent about 6¾ miles, and ample water-power can be obtained upon reasonable terms within easy distance of the town. Some further particulars will be found elsewhere, and tenders must be sent in to Mr. John F. O'Brien, Town Clerk, by the 25th inst.

——— The Board of Governors of the Killarney District Lunatic Asylum ask for estimates for the installation and supply of electric light to the asylum, the number of existing gas-lights exceeding 400. The Board will discuss these estimates at their meeting on May 18th. Communications have to be addressed to Dr. Griffin, the resident medical superintendent.

——— The Richmond Main Sewerage Board invite tenders for providing and fixing the necessary apparatus for lighting their works at Mortlake by electricity. Some particulars will be found in our advertisement columns, and all other information can be obtained of Mr. William Fairley, resident engineer, Main Drainage Works, Mortlake, S.W. Tenders must be sent in to Mr. J. Leslie G. Powell, Clerk to the Board, 13, The Green, Richmond, Surrey, on or before the 23rd inst.

——— The Council of the Borough of Brighton invite tenders for the supply and erection at their electricity works, North-road, of the central station switchboard and apparatus. Specifications can be obtained on application to the Town Clerk's office, Town Hall, Brighton. Tenders must be sent in to Mr. J. Tilstone, Town Clerk, before 10 a.m. on Monday, the 15th inst.

——— Tuesday next is the last date for sending in tenders for the wiring and supply of electric-light fittings for the central station of the Borough of Huddersfield. Tenders should be sent in to Mr. A. B. Mountain, Borough Electrical Engineer, Gasworks-street, Huddersfield.

——— The Manchester Corporation invite tenders for the supply of dynamos, engines, switchboards, cables, and lamps complete for the stores and chill rooms about to be erected in Elm-street, adjoining the abattoirs. Specifications, &c., may be obtained on application at the office of Mr. M. C. Bannister, 29, Princess-street, Manchester; and tenders must be in by the 23rd inst.

——— The Gas Committee of the County Borough of Salford require tenders for the erection of the buildings for their electric lighting station. These tenders must be in before 5 p.m. on Thursday, the 11th inst.

——— The Municipality of Péruwelz, Belgium, invite tenders for the concession for lighting the town by electricity. All information can be obtained from the Communal Secretary, and tenders will be opened at 2 p.m. on June 12th.

TENDERS ACCEPTED.—The Gas Committee of the Aberdeen Town Council have submitted the tenders received for the works and plant for the electric lighting scheme, and the following tenders have been accepted :—

Electric Construction Corporation (Limited), engines, dynamos, &c.	£5,044
Messrs. Simmons and Co., switch boards	990
Babcock and Wilcox (Limited), boilers	1,494
Electrical Power Storage Company (Limited), batteries	760
Messrs. Bolton and Sons, copper strip (about 30 tons)	1,820
The Callender Company, cables	1,532
British Insulated Wire Company (Limited), pilot wires	190
Messrs. Doulton and Co., insulators	177
Messrs. M'Kinnon and Co. (Aberdeen), iron roofs	410
Messrs. M'Kinnon and Co. (Aberdeen), iron battery stands	56

The building work has been given to local firms. The total contracts, including the buildings, amount to £17,918.

——— The tender of Messrs. Siemens Bros. and Co. has been accepted by the Derby Corporation for laying the mains, &c., with all accessories, for their electric lighting scheme.

——— The Gas and Electric Light Committee of the Burton Town Council have recommended the acceptance of the tender of Messrs. John Fowler and Co. of Leeds (in conjunction with Messrs. Hammond and Co. for the electric-lighting works). In moving the adoption of the report, which was subsequently carried, Alderman Lowe confidently anticipated that by Christmas the current would be obtainable for lighting purposes.

MICA.—Messrs. Wiggins and Sons have again secured the Admiralty contract for the supply of mica to that department.

SALE BY AUCTION.—Mr. Thomson, auctioneer, will sell at Pulrose Crossing, near Douglas, to-morrow (Saturday) unless previously sold in one lot, a quantity of electrical plant and apparatus, and also a complete electric lighting installation, consisting of a Robey engine, Crompton dynamo, and arc lamps, regulating apparatus, &c., which have recently been in use at the Panorama Buildings, Douglas, Isle of Man.

SALE BY TENDER.—Owing to the dissolution of partnership of Messrs. F. Reid, Nichol and Co., tenders will be received by Mr. Thomas Bowden, of 42, Mosley-street, Newcastle-on-Tyne, by noon on the 17th inst. for the stock of electric light wires, fittings, arc lamps, carbons, lightning conductors and fittings, bells and telephones, forming the stock of the dissolved firm. This stock will be on view at Forth House, Bewick-street, Newcastle-on-Tyne, from May 10th to 13th inclusive. Further particulars can be obtained of Messrs. Thomas Bowden and Nephew, chartered accountants, Newcastle-on-Tyne.

APPOINTMENTS VACANT.—The Corporation of Bristol require an assistant engineer for their Central Station at a salary of £2. 10s. per week. Further particulars will be found elsewhere, and applications must be sent to the Town Clerk, Electricity Department, 51, Prince-street, Bristol, by the 16th inst.

——— To-morrow (Saturday) is the last day for sending in applications for the appointment of resident electrical engineer for the borough of Wolverhampton. Applications should be sent in to Mr. Horatio Brevitt, Town Clerk.

PERSONAL.—Mr. R. H. Claxton, who has been for many years manager of the Liverpool district of the National Telephone Company, has been promoted to be superintendent of the North-Western system of the Company, and will have the control of Manchester and other large towns.

——— Mr. Robert Gilmour, who has been telephone superintendent at Aberdeen for some years past, has been promoted by the National Telephone Company to be superintendent of Dundee. Mr. Gilmour is succeeded at Aberdeen by Mr. Brown, of the Mid-Lanark or Hamilton telephone district.

BANKRUPTCY.—The total debts of Edward J. Bayly, lately carrying on business at Liverpool as an electrical engineer, have been returned at £152. 15s. 6d.

IRON AND METAL TRADES PENSION FUND.—The celebration of the jubilee of this fund will take place at the Guildhall, under the presidency of the Prince of Wales, on June 21st, and not May 11th, as previously announced.

TELEPHONE CABLES.—A telephone cable about 1¼ miles in length has been laid across the River Tay, at the point below Dundee, by Messrs. T. Smith, of Messrs. W. T. Henley's Telegraph Works Company (Limited), by which firm the cable was made for the National Telephone Company (Limited).

INDESTRUCTIBLE IGNITION TUBES.—The Indestructible Ignition Tube Syndicate (Limited), owners of Wellington's patents for gas and oil engines, &c., send us a sample of their ignition tubes, for which they claim many advantages—including endurance, instantaneous heating, ease of starting, and simplicity of fitting. The particulars issued show that the tubes are in use in a number of large business houses, and that they are being supplied to all the principal gas-engine builders, including Crossley Bros. and Tangyes. The tube appears to be made of a white porous porcelain.

WATERHOUSE ARC LAMP.—The Waterhouse Electrical Manufacturing Company send us some printed particulars and prices of the Waterhouse arc lamp. Copies of this list can be obtained from the Company's offices at 33, Old Broad-street, E.C., or from the works, 67, Southwark Bridge-road, S.E.

ANTWERP EXHIBITION.—Further printed particulars are to hand relating to the Exhibition to be held at Antwerp on May 5, 1894. Special competitions, meetings, and conferences will be held during the Exhibition, which has received the special patronage of the King of the Belgians and the official support of the governing authorities of the city of Antwerp. The Committee of the Exhibi-

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tion consists of the leading Belgian commercial houses. It is to be regretted that a lottery is to form a feature of the Exhibition, the prizes in which are to be purchased from exhibitors exclusively.

BRIDLINGTON.—The Local Board have resolved to expend £340 for a Crossley's "Otto" gas engine for supplying the motive-power for lighting Prince's Parade with electricity.

BRISTOL.—Mr. Preece, before the Electric Light Committee of the Bristol Corporation, stated that most satisfactory progress was being made by the contractors, and that the light would be supplied in August.

BLACKPOOL.—Dated April 24th, Mr. William Chew, electrical engineer to the borough of Blackpool, has forwarded a report of the working of the electric light stations, Nos. 1 and 2, to the Markets and Gas Committee. The report states that the manufacturing appliances have been maintained in good condition, the chief items of renewals consisting of switches, armatures, lamps, and lanterns. The distributing plant is in need of repair for the coming year. Working expenses have not reached the estimated cost, showing a surplus of £70. Taking the returns for 1892 of the nine leading London and Provincial electric-lighting concerns, Mr. Chew puts the highest cost for working at 8·92d. per unit, the lowest 3·43d., or an average of 4·81d., with the addition of dividend items. The net cost of the Blackpool supply was 3·46d. per unit for the current supplied to the public lamps. Careful investigation had proved that the demand for the light in June is about one-third of that in December. The number of private lights in use was 18 per cent. of the total, but private consumption represented only 5·25 per cent. of the year's output.

CHAGFORD.—The proprietors of the Chagford Gas Works have recently held an exhibition of gas appliances, with special reference to the advantages of cooking by gas. A competing exhibition is, we understand, shortly to be held, to show the greater advantages to be obtained by cooking by electricity.

CITY LIGHTING.—The City of London Electric Lighting Company give notice that application is being made to Parliament in the present session for a Bill to alter and amend the provisions of the City of London Electric Lighting Orders, 1890 and 1891, with respect to the keeping of accounts and setting aside all depreciations and reserve funds, and to provide that the undertakings covered by the various Orders shall be deemed to be one undertaking. The Bill also asks for the exemption of any building used by the City of London Company for the generation of energy from the operation of the Metropolitan Building Act of 1855, &c. Copies of the Bill were deposited in the Private Bill Office on the 1st inst. Mr. Sydney Morse is solicitor for the Bill.

COATBRIDGE.—The Scottish House-to-House Electric Lighting Company (Limited) have commenced laying the mains for the installation at Coatbridge, and promise the Town Council that current shall be supplied in about three months from the 1st inst. The Lighting Committee have under consideration the type of lamps and fittings to be supplied for public lighting.

DERBY.—As announced on the previous page, Messrs. Siemens Bros. and Co.'s tender for the laying of the mains, and supply of accessories, in connection with the electric-lighting scheme of the Corporation, has been accepted, and considerable progress has been made during the last few months with the works and buildings. Messrs. Bramwell and Harris, the consulting engineers, report that the light will be ready for supply by about the middle of July next. Arrangements have already been entered into for introducing the electric light into the Free Library and Reading Rooms.

DORCHESTER.—Arrangements are being made for lighting the town of Dorchester by electricity.

DUNDEE.—The Finance Committee of the Gas Commission have received permission from the Secretary of State for Scotland to borrow a further £1,000 for the purposes of works under the Dundee Electric Lighting Order of 1890, making the total amount borrowed under this Order £30,000. In conveying this sanction it was pointed out that on the further borrowing powers now conferred being exercised, an additional sum of not less than £175 should be carried annually to the sinking fund for paying off the money raised for electric lighting purposes. The money has been borrowed at 3¼ per cent. for a period of four years.

EXETER.—The Devon Standing Joint Committee having discussed the advisability of introducing the electric light into the whole of their offices, it was decided to consult the electrical engineer of the local electric lighting company, and make a report at the committee's next meeting. It was, we learn, ultimately decided to light the county clerk's offices.

GLASGOW.—A specimen of the new tramway car, which is to be adopted by the Glasgow Corporation on taking over the tramways in July, 1894, has recently been submitted to the Council for inspection. It is to be lighted by two electric lamps, and other improvements in tramway car arrangements are to be adopted. We understand the Brush Company are manufacturing the cars.

HANLEY.—On Tuesday last the Town Council discussed the advisability of substituting 30 1,200-c.p. arc lamps, in lieu of the 2,000-c.p. lamps originally specified for street lighting, to take the place of the large gas lamps at present used in the principal thoroughfares; it was also decided that the mains for incandescent lighting be laid down at the same time as the arc-light mains. An electrical engineer, to have charge of the construction of the works at a salary of £200 per annum, is to be appointed, the selected candidate to devote the whole of his time to the duties.

HOTEL LIGHTING.—Mr. W. Cornhill, Kinloch Arms Hotel, Carnoustie, Scotland, has had the electric light installed throughout his hotel. The light is giving great satisfaction. The plant consists of a Mather and Platt dynamo, and a 4½ H.P. engine. The work has been done by Mr. J. Anderson, of Carnoustie.

ISLE OF WIGHT.—The West Cowes Local Board have received a letter from the Secretary of the Isle of Wight Electric Lighting Company, in which he refers to the want of public interest shown by the residents of Cowes in the proposed electric lighting works, and the difficulty the Company has experienced in securing the necessary capital. Under these circumstances, although the Company had a considerable amount subscribed, it would not justify them (in the opinion of the Directors) in going forward without further financial assistance. The Directors, therefore, left it to the Local Board to take such steps as they thought fit, and hoped the Board would allow the matter to remain in abeyance for a short time longer to enable them to make another effort to raise the necessary capital. The matter was referred to the Lighting Committee.

LARNE.—The Town Commission have had under consideration an offer from the receiver and manager of the firm of Messrs. J. E. H. Gordon and Co. (Limited), relative to the purchase of the electric light installation at Larne for the sum of £8,000, payable in cash or in town stock. It was stated that the working expenses of the installation amounted to about £300 per annum, and that the income was in excess of that figure. After some discussion a resolution declining to purchase was carried.

LIVERPOOL.—The *Liverpool Mercury* of the 29th ult. contains an account of a visit to the new switch room of the National Telephone Company of Liverpool.

MANCHESTER.—A considerable addition is being made to the arc-light installation at the Zoological Gardens, Bell View, Manchester. The arc lamps are of Richardson's differential clockwork type, lighthouse pattern. Mr. A. W. Richardson, of Patricroft, has supplied the whole of the plant from the first.

MIDDLESBOROUGH.—In reply to requests from several users for permission to carry electric light wires overhead, the Middlesborough Corporation have decided that on no consideration whatever will overhead electric light wires be allowed in the town.

NEWCASTLE.—The report of their architect to the Cox Lodge Asylum Committee was discussed at the last meeting, and the estimate of cost for lighting the Asylum either by gas or electricity was put at an equal figure. The electric light will, of course, be selected. The question of motive-power is for the present deferred.

NORWICH.—The extensive premises occupied as a boot store by Messrs. Stead and Simpson, known as St. Andrew's-chambers, have been fitted throughout for the electric light, the current being supplied by the Norwich Electricity Company, under the superintendence of Mr. Pretty, the Company's engineer.

OSWESTRY.—Further progress has been made in the establishment of a local electric light and power company for Oswestry, and there is now no doubt that the project will be carried out.

SOUTHAMPTON.—About 400 electric lamps are fitted at and about the new Empress Dock, and there are already 20 3,000-c.p. arc lamps, and nearly all the mains are laid. Two additional 3,000-c.p. arcs have been erected on that part of the quay used by the American liners, and the whole of the installation is approaching completion. One of the sets of combined engine and dynamos has been running for some time past, and is giving great satisfaction; two further sets will be in working order by the end of May. Messrs. Crompton and Co. (Limited) are the contractors for the work, which is being done under the supervision of Mr. B. H. Jenkinson.——A sub-committee, appointed to inspect the electric cranes which are being supplied to the Docks, have, through the Mayor, expressed to Messrs. Statter and Co. and to Messrs. Stothert and Pitt their gratification at the success of these cranes. No. 1 of which is now completed, No. 2 being well in hand. The Committee saw the crane at work, and it will be fitted at Southampton next week.

SOUTH SHIELDS.—The Corporation have decided to carry out the electric lighting scheme for which they obtained an order about two years ago. A report has been presented by Mr. E. J.

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Jennings, in which he estimates that plant for the supply of 6,000 lamps would be sufficient for lighting the streets in the compulsory area, but that provision will have to be made for a probable extension necessitating about 2,000 additional lights. He estimates the cost of the necessary works at £14,000, and that 5¾d. per unit would be a sufficient charge to pay interest and working expenses. It will be necessary for an extension of time to be applied for by the Corporation in order to carry out the details of the scheme.

WEST HAM.—With regard to the report presented by the Works Committee recommending the Council to proceed to put in force the Provisional Order obtained in June last, the Council have decided not to adopt the report, and have referred it back to the Committee for consideration, with a view to a scheme being prepared for the establishment of a central station.

WORCESTER.—At the last meeting of the Guardians a discussion arose on the decision of the Building Committee to postpone the introduction of the electric light into the new workhouse. It was the opinion of a number of the members present that electric light for the public buildings was very desirable, and that the matter should not be shelved. In the result the report of the Building Committee was, however, adopted.

COMPANIES' MEETINGS AND REPORTS.

Brazilian Submarine Telegraph Company (Limited).

The thirty-ninth ordinary general meeting of the shareholders of this Company was held at Winchester House, Old Broad-street, London, on Wednesday, May 3, 1893, the Hon W. St. John Brodrick, M.P., presiding.

The SECRETARY (Mr. Richard Collett) read the notice convening the meeting and the minutes of the thirty-eighth ordinary general meeting held on October 19th last. The report of the Directors was taken as read.

The CHAIRMAN: I will now proceed to make a few remarks in moving the adoption of the report and accounts. Before doing so, however, I cannot help expressing to you the regret which we feel that our Chairman, Sir James Anderson, is unable to be here to meet you to-day. I am sure that all those who know that Sir James Anderson has been suffering for some weeks from very severe illness will greatly regret his absence. We are all aware of the great advantage which this Company, from its formation to the present day, has gained by the experience and attention which Sir James Anderson has brought to bear on its business, greatly to the advantage of the Company and the help of the Board. As regards the report and accounts, our revenue for last half-year exceeded the revenue for the preceding half-year by a little over £2,000. That increase, however, is rather apparent than real, because a certain sum came into the accounts of the last half-year which had been held in suspense in the preceding half-year, and which would have altered the balance. Comparing our revenue of December, 1892, with the revenue received in the half-year ended December, 1891, we have a decrease of £13,000; but, on the other hand, we have a decreased expenditure this half-year of something like £5,000, although we have had to meet some unusual calls in connection with our staff quarters at St. Vincent. In the previous half-year we had to meet other calls in connection with the duplexing of cables and repairs, which have not occurred to the same extent this half-year. I should like to say a word to explain the expenditure at St. Vincent. We have had to put on a considerable increase of staff there, in consequence of the large amount of business to be transacted, and the establishment of a day and night service, as well as the increase of business which comes from the West Coast of Africa and the Cape Colonies. That has necessitated an extension to our station, the expense of which has fallen, to a considerable extent on the half-year under review. In addition to that, the Board, after carefully considering the subject, came to the conclusion that it would be necessary to erect tanks and tank sheds and machinery at St. Vincent for keeping spare cable there, and the shareholders will be able to appreciate the foresight which dictated that operation when they consider the instance of the repair which, I am glad to be able to announce, has just been executed in connection with the removal of a fault in cable No. 2, near Pernambuco. We chartered the nearest and the most easily available telegraph ship to repair it. She was at the time on the west coast of Africa. She called at St. Vincent, and there took in the necessary cable, and proceeded direct to the scene of the fault, which was removed on the 28th of last month, and she was able to return without even touching at South America. The economy created by having the cable ready at St. Vincent, so that the ship had not to come to England for it, has been very considerable, and has already justified the expenditure which we were put to at St. Vincent, which in the half year came to £2,600. Since the last meeting other repairs have been executed in the No. 1 cable from St. Vincent to Pernambuco, and in the No. 1 cable from St. Vincent to Madeira, and we have laid down very heavy cable for shore ends at Madeira. It is the hope of the Board that the cable now laid down will be found sufficiently strong to resist the very heavy surf which in certain gales besets the coast of Madeira. The shareholders will be glad to know something with respect to the opposition we have had from the South American Cable Company. You are aware that a Company has been established connecting Senegal with South America, which may be considered to be in opposition with this line. The South American Cable Company opened on October 5th last and operated until December 27th. On December 27th a break occurred in their cable, which was totally interrupted until February 9th. Recently notice has been given by the South American Cable Company of a decrease of rates, to take effect from April 1st last. After consulting the Western and Brazilian Company, the Board decided to adopt similar rates to those of the South American Cable Company, and as the object of that Company is to take our traffic, the Board will, if necessary, continue in conjunction with our allies to reduce rates to the level notified by the opposition. We have very carefully considered the effects of this opposition and of the working hitherto, and the experience gained of this working does not make the Board greatly fear the loss that may be incurred by this competition. There is one subject which is extraneous to the usual business of the meeting, on which I have to address a word or two to you. We propose to ask your leave to establish a fund for the pension and superannuation of *employés* of the Company. Gentlemen, you will be aware that the Eastern Company, the Eastern and South African Company, and the Eastern Extension Company have all adopted superannuation schemes and a pension scheme recently on the same basis. Their proposal has been—and we intend to ask the shareholders to adopt the same—that the pension fund should be established by a contribution of 2½ per cent. from their salaries by every member of the staff under a certain period of service, and that the Company should then add 2½ per cent. to meet that contribution. We have reason to know that the arrangement so made will be satisfactory to the staff, and will also provide, after many years of service, an adequate pension to those employed. The superannuation scheme is a little different. That has to do with the older members of the staff, who, if they were now put on a pension scheme, would not by their contributions supply a sufficient amount to provide in any way for their old age. There are two objects to be achieved in respect to this contribution. In the first place, it will be remembered that we are working with the Eastern Telegraph Company, that we have a joint telegraph station with them at Lisbon and Carcavellos, and a joint training establishment; and it will be obvious to every one that it would be undesirable, and might cause the loss to this Company of really good and useful men, if we were in a less favoured position than the Companies with which we have working agreements. The other object necessary to dwell upon is that we have to start a pension scheme not merely following what has become the practice of our colleagues—if I may so call them—of the telegraph world, but following the general principle which has been adopted by all public establishments and in the public service in the present day. Great schemes for superannuation and pension have been adopted quite recently in many of the largest public establishments, and it is not merely desirable, but it is a distinct advantage to the Company that we should do the same. We should have something of a hold on valuable men, so that when they have given us a certain period of service they should not be induced to transfer their abilities elsewhere, but should have the certainty of their contribution and our contribution to the pension scheme to induce them to remain in our service. Now, the shareholders will naturally ask me what is going to be the expense of this scheme. That matter we have carefully considered, and have had reported on by actuaries of eminence. The shareholders voted on the 20th of May, 1881, towards an insurance fund—a sum not to exceed £800 a year. We have never exceeded that amount, and it will in the future still suffice for the payment towards the superannuation of the older members of the staff proposed under this scheme. In addition to that, for the younger members of the staff we propose to meet their contribution by a contribution of 2½ per cent. on our own part, and that will cost, at the present rate of the salaries, about £500 a year. I do not think that the shareholders will feel, having regard to the nature of the occupation, the number of those employed, the fact that a great deal of our service is tropical, and the very extended operations of the Company, with its large revenue, that £500 is an undue amount to pay for the advantages which I have just described; and I am quite certain, after the fullest consideration, that we shall find it a prudent and economical operation, and in the best interests of the Company. I need not say anything more except that the shareholders will be able to gather from the report which we have submitted, and from the accounts, that the position of the Company continues to be very strong, and that we have a substantial reserve fund. Our property is in a stable condition in the market, our shares are at a premium, and remain firm, and the policy which has been pursued is, I think, the best guarantee of security for adequate dividends in the future. I need hardly say that the Directors will do everything in their power to ensure a continuance of their security. I now propose the following resolution:—

"*That the report of the Directors and the accounts to December 31, 1892, now submitted, be approved and adopted.*"

Sir HENRY D. GOOCH, Bart., seconded the motion.

Mr. W. GRIFFITH said he desired to endorse the policy of the Directors as to the pension and superannuation funds. They had already adopted the principle of the proposal in respect to their older servants, and they were, therefore, merely extending the principle. He thought they must all admit the advisability of having in the service of the Company gentlemen who were contented and who were likely to remain with them. In looking over the accounts he had been rather struck at the large amount put to reserve fund—£35,000—in view of the fact that their system was in such good order that there seemed very little likelihood of their being called upon to lay any other cable at present. Moreover, they had already paid off a very large portion of their debentures, and they would be able later on to raise money easily. The state of their property and the small mortgage on it rendered it less necessary for them to have so large a reserve fund, and he thought that the shareholders would be only too happy if the Directors would consider the advisability of increasing their dividends, more especially as, according to what the Chairman himself had said, the prospects of the Company

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were so good. Of course, what he had said was by way of suggestion rather than anything else.

The CHAIRMAN: Mr. Griffith has called attention to a very well-worn subject, that of the reserve fund. I am glad, in the first place, that he approves the superannuation fund, of which, as he said, the principle has already been established. No doubt the reserve fund stands at a very high figure, but I would venture to remind you that our No. 1 cable—although, as far as we know, it is in excellent condition—is between nineteen and twenty years old, and we must prepare ourselves some day for the renewal of that cable. In addition to that we have now to meet some extra charges in the present half-year for repairs of cables. We have consequently thought it desirable and prudent to recommend you to put to the reserve fund the sum mentioned, but I need hardly say that if at the close of the year we find ourselves in a position to pay more to the shareholders, no one will be more glad than the Directors to do anything that is prudent. However, I really think that the policy we have adopted in respect to the reserve fund has had a great deal to do with strengthening our hands against competition, and in preserving our shares in the satisfactory position which they now stand at in the market.

Mr. NEWMAN said he quite agreed with all the Chairman had said as to the reserve fund, which he thought could not be too large. He had always advocated that principle from the beginning, for if they had a large reserve fund they would always be independent of opposition. He hoped the Directors would continue to add to the reserve fund year by year.

The CHAIRMAN then put the resolution to the meeting, and it was carried unanimously. He afterwards proposed—

"*That the report of Messrs. Neison and Schooling, of the Institute of Actuaries, relative to the establishment of staff pension and superannuation funds having been submitted to the meeting, the Directors be and they are hereby authorised to cause such deed or deeds or other documents to be prepared as they may consider necessary for carrying out the scheme embodied in the said report, with such alterations and modifications, if any, as may be approved by the Directors.*"

That report is on the table, and it is a lengthy document, but I have given you the effect of it as regards finance. I thought that the shareholder would prefer not to be troubled with a long disquisition on the report, but, of course, any shareholder can see it at any moment, if he desires to do so at the office.

Mr. JOHN NEWTON said it had been suggested that the seconding of the resolution would come better from the shareholders' side of the table than from the other side. He therefore desired to second it as one who had benefited considerably in a small way from his investment in telegraph companies through the exertions of their staffs. He was confident that shareholders in a company like theirs would be glad to support, and to support cordially, such a scheme; and he was especially glad to see that the interests of the older members of the staff were not overlooked. It was to them, owing to their early labours, that the shareholders were considerably indebted.

The CHAIRMAN then put the motion, and having declared it carried unanimously, added that that concluded their business that day.

Mr. NEWTON proposed a vote of thanks to the Chairman and Directors for their services. In moving the resolution on the present occasion he thought that they ought to express their great regret at the serious illness of Sir James Anderson. He trusted that their Chairman might soon recover, and that the shareholders might again see his pleasant face among them. (Hear, hear.)

Mr. GRIFFITH seconded the motion. They were in a very prosperous state, and were greatly indebted to their Directors for this. He also re-echoed the wish expressed by Mr. Newton regarding Sir James Anderson. Perhaps the Directors would convey to him their expression of condolence.

The resolution was carried unanimously.

The CHAIRMAN: Mr. Newton and gentlemen, on behalf of my colleagues and myself, I thank you very much for your kind expression of confidence. I can assure you that we shall do everything in our power to preserve the Company in its present efficient and substantial condition.

The proceedings then terminated.

Indo-European Telegraph Company (Limited).

The twenty-sixth ordinary general meeting of the members of this Company was held at Winchester House, Old Broad-street, on Friday last, under the presidency of Mr. J. Herbert Tritton.

The MANAGING DIRECTOR (Mr. W. Andrews) having read the notice calling the meeting,

The CHAIRMAN said: I beg to move,

"*That the report and accounts now submitted be received and adopted and that a dividend be and is hereby declared for the half-year ended December 31, 1892, of 17s. 6d. per share, making, with the interim dividend already paid, 6 per cent. for the year, and a bonus of 20s. per share, both free of income-tax, making in all 10 per cent. for the year.*"

Gentlemen, there is again very little to be said upon the report and accounts of our Company for the year 1892. It may, perhaps, be as well for me to direct your attention to the total of the expenses account under maintenance in the revenue account—£30,188. This apparently shows an increase, arising, however, from our having written down the cost of certain more or less obsolete plant and apparatus for which we thought the year offered a favourable occasion. This policy is merely a continuance of former measures in the same direction, only that the sum that had to be dealt with was rather larger. As a fact—and you will be glad to hear it—I may say that there is a slight reduction in the actual working expenses. There are increases under the heads of salaries and wages, and for station expenses, and travelling connected with the message department, and removals of clerks; and diminutions under other heads, which it is not worth while to refer to. The revenue in the aggregate shows an increase of about £700. Adding the amount brought over from last year of £5,983 to the gross revenue, amounting to £117,479, after deducting expenses, crediting £10,000 placed to the reserve, and after deducting the interim dividend, there remains a balance of £39,432 available. This, as you have heard from the resolution, and seen from the report, the Directors propose to apply by declaring a dividend for the last six months of 17s. 6d. per share, and a bonus of 20s. per share, both free of income tax, and to carry forward £7,557 to the credit of 1893. This is the practical outcome of the year's working, and I have no doubt you will agree that it is a very satisfactory outcome indeed. The gross receipts for Indian business are still below those of the year 1886, when the reduction took place in the tariff, although the number of words is greater. The fact appears to be that in an old-established country like India, there is a very different state of things to that pertaining in younger and rapidly-growing communities. There may be, and are, of course, fluctuations and periods of greater or lesser activity, but the rapid growth all round is wanting. On the other hand, the great reduction of rates made with Australia has had for result a very large augmentation of the number of words transmitted, and I think it is not too much to assume that if the reduced rates had been let alone, the former amount of revenue would have been recovered in a very few years. The Colonies, however, found it necessary, owing to circumstances that will be in the mind of every one, to take steps to diminish the losses that were being sustained, and an addition of 9d. per word was made to the lowered rate in order to get back not all the loss, but some of it. This small addition still left the rates very low for the enormous distance traversed. This Company hopes and believes that this small addition will by-and-by be knocked off again. The pause in the advance of the great Australian Colonies which we are now witnessing, however trying at the present moment the process may be, is salutary and even necessary. Our friends have to learn that the development of their immense territories and resources must be their first object, and that the adage of "Australia for the Australians," if persisted in, will be their ruin. They must encourage settlement on the land in order to develop their exports. They must ensure wisely-directed and not improvident expenditure, and they must re-establish by rigid economy that credit which will enable them eventually to take the lead in the commerce and production of the world. The working of the lines continues to be most satisfactory, as well in India as throughout the Indo-European system of the Indian Government and the Company. Shareholders should not in my judgment fail to remember that prosperous as the Company is, there are yet contingencies which must be reckoned with in estimating the position and future of the Company. I now move the resolution which I have already read.

Mr. H. WEAVER seconded the motion.

The CHAIRMAN said he would be happy to answer any question. If there were no questions to be asked he would put the resolution, which was carried unanimously.

Mr. Earle and Mr. Holland were re-elected as Directors, and Messrs. Kemp, Ford and Co. as auditors.

On the motion of Mr. G. VON CHAUVIN, seconded by Mr. STEPHENS, a vote of thanks to the Chairman and Directors was passed, and the proceedings terminated.

West Coast of America Telegraph Company (Limited).

The sixteenth ordinary general meeting of this Company was held on Tuesday last at Winchester House, E.C., Mr. J. Denison Pender (Chairman) presiding.

The SECRETARY (Mr. Fred. L. Robinson) read the notice convening the meeting, the report of the Directors and statement of accounts being taken as read.

The CHAIRMAN said: Gentlemen, in moving the adoption of the report and accounts for the year 1892 I will refer to some of the items in the accounts. The large decrease in the gross receipts of the Company is, as you are aware, owing to the fact of your cables and land lines having been practically isolated from the outside world, and the traffic almost wholly confined to local work, at reduced rates, consequent upon the competition of the American Company at Lima, Iquique, Valparaiso, and Santiago, our principal stations. The receipts have also been affected by the continued depreciation in the value of the currency. Turning to the other side of the accounts, your attention has been drawn in the report to the reduction in the gross expenditure of about £2,500, as compared with the previous year. This reduction is attributable to economies effected on the West Coast, and to the comparatively small outlay for maintenance of the cables and land lines, notwithstanding that this item includes the greater part of the cost of reconstructing the land lines between Valparaiso and Santiago, and the expenses connected with taking over new and more commodious premises at Valparaiso. During the past year the cables were only interrupted on two occasions. A fault appeared in the shore ends at Iquique in June, and the northern section between Mollendo and Lima was broken by an earthquake in November, the necessary repairs being in each case promptly effected by the repairing steamer "Retriever." The steamer is stationed at Callao, and is, I believe, kept up to the highest degree of efficiency. With regard to the extension of your cable to Talcahuano, which is one of the most important works carried out during the twelve months under review, this matter has received the earnest attention of the Board for some time past. Our customers on the West Coast want a more reliable service between Valparaiso and Concepcion than at present exists, and the extension was also strongly urged by the late Chilian Minister. A concession was, therefore, obtained from the Chilian Government for a cable from Valparaiso to Talcahuano, about 277 knots, with a land line from Talcahuano to the city of Concepcion. This

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land line is just completed, and a cable of the most approved type was shipped to Talcahuano in February. From the sailing vessel which carries it out it will be transferred to our steamer "Retriever," and laid under the superintendence of our manager, Mr. Bailey. As to the probable earning power of the extension, we are advised from Valparaiso that we shall have a very considerable amount of traffic over the line. Most of the important English and German houses have established branches in Concepcion and Talcahuano, and the wheat season will give us plenty of business. The principal Valparaiso firms send more telegrams to the south than to any part of the coast, and with a good reliable service we are assured that their telegrams will be trebled. At the last general meeting you were informed that the negotiations with the Brazilian Submarine, and the Western and Brazilian Telegraph Companies, conducted under the auspices of Sir John Pender, G.C.M.G., had resulted in the formation of a new company, the Pacific and European Telegraph Company (Limited), the share capital of which is held by the two Brazilian Companies and this Company. The duplicate line to be run by the new Company from Buenos Ayres to Valparaiso and Santiago, is approaching completion, and will be taken into our offices at Valparaiso and Santiago and worked by our staff, a proportion of the station expenses being borne by the new Company. Now I have given you the present position of the Company; but let me go back to the past, and, although I am not going to prophecy, I wish also to give you my ideas as to the future, and my reasons for forming those ideas. In the case of a new company which has not paid any dividend, the shareholders, after a time, begin to get sick of it; but in the case of a company that has paid a dividend, and a good dividend, such as the West Coast of America Company has done, it is a great pity to see it, from no act whatever of the direction, fall into the list of non-dividend paying concerns. You will remember that your late partner—the Central and South American Company—worked with you for a considerable time under a certain agreement, and the expenses of your ship were paid for by both companies, which was a considerable saving. One fine day, without any rhyme or reason, you got notice to terminate that agreement. Your Board at the time offered to do everything in their power to prevent another cable, which was not required, from being laid along-side yours. I believe they went so far as to promise to hand over the entire working of the West Coast of America Company to the Central Company on condition that the debenture interest, which is very heavy, namely, 8 per cent. on £150,000. and a certain dividend to the shareholders should be guaranteed out of the first receipts. However, the only answer received to that offer was that the Central Company had made other arrangements. Your Directors then looked about to see what could be done. Directly they found that your lines were likely to be cut off from their former communications they applied to Sir John Pender, who is connected with the largest telegraph systems in the world, and he took the matter up, and tried to negotiate with the Central Company, but without avail. Then Sir John and several other gentlemen endeavoured to buy the Trans-Andine line, but they found that the other company were bidding for it also. Our combination bid a little more than the cost of this Trans-Andine line, taking it that, as a going concern, it was perhaps worth a little more; but their efforts were of no avail whatever, and so the matter was left alone, and the Trans Andine was finally purchased by the Central Company. However, immediately after the sale had taken place to our competitors, a company was brought out, with Sir John Pender and several other gentlemen on the Board, and concessions were procured to get a new line laid from Buenos Ayres to Valparaiso. That line has been in course of construction for some months, so that in about two, or, at any rate, three months it will be opened for traffic, and you will therefore have again the means of communication from the West Coast of America to Europe, and be in a much better position. In the case of this new line that is being made, the debenture interest is guaranteed by the West Coast and the two Brazilian Companies, and therefore you are not only bound to them by a working agreement, but you are bound also financially, which perhaps makes a stronger bond between you than any other. It does not stop there. I believe it is a known fact in railway organisation and railway working that expresses running between, say, two of the largest cities would not be remunerative to the companies concerned, but it is the feeders into these cities, and the feeders to the principal stations, that fill up the trains. This is even more the case in telegraphy, because although long lines between two points, would not pay by themselves, the different feeders into the towns or countries at which the main cable touches help very materially to make them pay. Your present position is this: you are now closely connected with the Brazilian Companies, which, in their turn, work with the Eastern Telegraph Company and the Eastern Extension Telegraph Company, and through the working rights which exist between all these Companies you have become part of the largest system in the world. I am not going to prophesy, but I have simply stated what I know about your position, and I leave you to form your own opinion about it. My confident belief is that the West Coast of America Company is on the eve of being placed in a better position than it has ever been in before. I believe that what I have said, and the description I have given, will go to the shareholders who are unable to be present, and I hope it will have the effect of preventing them from throwing their shares on the market and abandoning the Company. I now beg to move:—

"*That the report and the accounts to December 31, 1892, now presented, be received and adopted.*"

Mr. HENRY ROBERTS seconded the motion, which was carried *nem. con.*

On the motion of Mr. ROBERTS, seconded by Mr. PACE, the retiring Directors, Mr. J. Denison Pender and Mr. Frederick Walters, were unanimously re-elected to their seats at the Board.

The auditor, Mr. John Francis Clarke, was also re-appointed, and a vote of thanks having been accorded to the Chairman and Directors, and briefly acknowledged by the former, the proceedings terminated.

Great Northern Telegraph Company.

The following is an abridged report of the proceedings at the general meeting held at Copenhagen on the 29th ult., F. Zahle, Esq., presiding:—

The Chairman of the Company, C. F. TIETGEN, Esq., in rendering an account of the working of the Company during the year 1892, referred to

The Company's Cables, which, he said, had remained in very much the same condition as the previous year. In Europe there had been eleven interruptions, one of which, on the cable connecting England with Norway and Sweden, was remarkable as being the first interruption of that cable since its submersion twelve years ago. The cable steamer "H. C. Orsted" had been on active service for 104 days. In the Far East there had been thirteen interruptions of the cables, and the Company had, when effecting the necessary repairs, taken advantage of the opportunity to renew and strengthen the cables in the most exposed places. This applied especially to the cables between Shanghai and Nagasaki. The value of the spare cable thus employed had been debited to reserve fund account. The cable steamer "Store Nordiske" had been engaged on cable work for 258 days, 90 of which had been for account of others, including the Government of Hong Kong, for whom a cable had been laid between Hong Kong and the recently-erected lighthouse on Gap Rock Island.

Working Account.—He considered this the right place to mention an alteration that had been made with regard to the way of dealing with the profits and expenses of the cable steamers in the accounts. Hitherto the profits accruing from the hire of the cable steamers had been deducted from the expenses, which might give rise to misapprehension, as in consequence of this deduction the accounts did not show the amount of the actual expenses. In last year's account, however, this had been put right, and no deduction had been made under the item "ordinary supervision and maintenance of the sea and land lines and repairing steamers 'H. C. Orsted' and 'Store Nordiske,'" whilst the money earned by the cable steamers had been taken into account under "sundries." This would explain the apparent increase of those two items.

The Situation in China.—For some years he had had very little to communicate to the shareholders with regard to the situation in China, and the relations between the Company and the Chinese Telegraph Administration. The so-called Chefoo agreement had never come into force. As explained on former occasions, the chief object of this agreement had been to reconcile the interests of the new telegraph route, which the Chinese were anxious to open up by way of the Siberian frontier, and the interest of the two old routes, which connect Europe with China by means of submarine cables. As long as the new line had not been put into operation by the junction of the Chinese and Russian telegraph systems, the Company had had no difficulty in dispensing with the agreement. Last autumn, however, a convention with regard to this junction had been concluded between Russia and China, in which the principles regulating the future relations between the different routes had been laid down in a very impartial spirit. In accordance with the fundamental rules of the International Telegraph Convention, it had been stipulated that the three routes should transmit telegrams at equal rates, and there would thus be no competition of rates, but only a competition as to the efficiency of the respective lines. A uniform rate of 8.50fr. per word had been fixed by all three routes between any place in Europe and any place in China, which represented both a simplification of the rates and a reduction for all towns in the interior of China. The new route had been open for traffic since March 1st last. The competition thus inaugurated would probably have the effect of decreasing the revenue of the old routes, and especially that part of it which was derived from the limitrophe correspondence between Russia and China. Still, provided the stipulations of the Russo-Chinese Convention were loyally carried out by the Chinese, the Company felt so confident of the superiority of their own service that they had no serious misgivings on this head.

Financial Results.—After all, however, matters called for great circumspection and caution, the more so as the traffic receipts were over £21,000 lower than the previous year. This was partly due to the fact that the reduced rates fixed at the International Telegraph Conference at Paris, had been in force the whole of 1892, whilst in 1891 they were in operation during the last six months of the year only. It was also partly due to the continually-decreasing rate of exchange of the silver dollar, which affected the Company's remittances from the Far East in a very marked manner.

Distribution of Profits.—These considerations rendered it advisable to place the same amount as last year to the credit of the reserve fund, whilst the Board of Directors had been enabled to recommend that the total dividend be fixed at the same amount as for the two previous years, viz., 17s. 2d. per £10 share, or about 8·60 per cent.

The following resolutions were submitted to the general meeting, and carried unanimously:—

"*That the report and balance-sheet, together with the propositions as to the distribution of the balance, be adopted and discharge given to the Board of Directors.*"

"*That the retiring Director, M. Melchior, Esq., be re-elected as member of the Board of Directors.*"

"*That A. Berner, Esq., and S. Bille, Esq., be re-elected as auditors of the Company.*"

Submarine Cables Trust.

The twenty-second ordinary annual meeting of the certificate holders in the Submarine Cables Trust was held yesterday (Thursday), at the offices of the Trust, Winchester House, E.C., Sir John Pender, G.C.M.G., M.P., presiding.

The SECRETARY (Mr. A. Brodrick) read the notice covening the meeting and the minutes of the last meeting, which were signed as correct.

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The report of the Trustees having been taken as read,

The CHAIRMAN said: The revenue for the past year amounted to £23,102, as against in 1892 £22,799, showing an increase of £303. The income derived from our investments in the Eastern and Eastern Extension Telegraph Companies is the same as last year, but there is an increase of £307 in that derived from our investment in the Anglo-American Stock. The expenses of the year amounted to £1.627, as compared with in 1892 £1,186, or an increase of £441. This is due to the appointment of two additional Trustees which was made at the ordinary meeting last year, and the legal expenses in connection with the alteration of the Trust deed and the transfer of the investments of the Trust in the names of the additional Trustees. Our revenue during the year has enabled us to pay two coupons of £3 each, and to pay off an additional 7s. 6d. of the overdue coupon. There remains still a balance of £1. 10s. in arrear, but should the dividend on our investments be maintained this arrear will be gradually paid off. I may mention that we received one letter in regard to the appointment of two extra trustees; but this is not a question of Directors; it is a question of trustees, and we are bound by our Articles of Association to appoint them. Our solicitor informs us that we must act strictly in accordance with these, and that accounts for the circumstance. The prosperity of the Trust depends entirely on the successful working of the different submarine cable companies in which we hold investment. Some of these at present are looking very healthy, and with the increasing prosperity of telegraph companies generally, we hope that this Trust's dividend will be maintained. He concluded by moving the adoption of the report.

The Marquis of TWEEDDALE seconded the motion, which was carried unanimously.

The auditors—Messrs. John G. Griffiths and John Gane—were re-appointed, on the motion of Mr. SHUTER, seconded by Mr. CUNLIFFE OWEN; and a vote of thanks having been passed to the Chairman and Trustees, which the former briefly acknowledged, the proceedings ended.

African Trans-Continental Telegraph Company (Limited).

The first ordinary general meeting of this Company was held on Thursday last week at 19, St. Swithin's-lane. Mr. Albert Grey presided in the absence of the Duke of Abercorn.

The SECRETARY (Mr. C. H. Weatherley) read the notice convening the meeting.

The CHAIRMAN said: This meeting is the first ordinary general meeting of the Company, and is purely formal. As no Articles of Association have yet been adopted it is necessary for the Directors to place their resignation in the hands of the shareholders. These gentlemen offer themselves for re-election. He then stated that a capital of £140.000 has been secured, this being the sum estimated to be necessary for carrying their telegraph line as far as Uganda. You will be glad to hear that the material for the first 400 miles has been ordered, and will in a very short time be shipped, one half going to Chinde Mouth, and the other half to Beira, for transport to Salisbury *viâ* the Beira Railway, arrangements having meanwhile been made in South Africa to construct the line from Salisbury as far as Zomba, the British Residency in Nyassaland. Thus you will observe that the first step has been taken towards the construction of the telegraph which is eventually to connect Cape Town with Cairo. I think it right to mention that by far the greater part of the capital has been provided by Mr. Rhodes, who, with unexampled generosity, has undertaken to find such portion of the £140,000 as may not be forthcoming from other quarters by the end of June. I trust this example of patriotism is one which wealthy capitalists in England will take to heart. I confess, speaking as an individual Englishman, and not as a Director of this Company, I am jealous for the sake of England that the honour of constructing this Imperial telegraph, required in the interests of the Empire and for the service of humanity, should belong so exclusively to an Englishman, however distinguished he may be, whose home is in South Africa. I am convinced that there are in this country large numbers of people, both great and small, who would dearly covet the privilege of being allowed to co-operate with Mr. Rhodes in the promotion of this Imperial undertaking. I believe the only reason why many have not already subscribed is that they do know how to avail themselves of the opportunity which is still before them. It was the ambition of Mr. Rhodes to get the money required for this telegraph subscribed in small sums, so that he might have the satisfaction of knowing that the people of England were at his back. I hope that this legitimate ambition may be gratified. I have now to propose—

"*That the retiring Directors, his Grace the Duke of Abercorn, K.G., and Messrs. C. J. Rhodes, Albert Grey, Rochfort Maguire, S. Neuman, and J. Werner, be and the same are hereby re-elected as Directors of this Company.*"

This resolution was proposed by Mr. PADDON, seconded by Mr. WATKINS, and unanimously adopted.

Elmore Patent Copper Depositing Company (Limited).

Mr. J. J. Atkinson presided on Friday at the adjourned meeting of the Company, and explained that the meeting had been adjourned for the purpose of electing a committee to confer with the Board in order to get the capital subscribed to carry on the Company, and to receive the resignation of the old Directors. That resignation was tendered, and the gentlemen who proposed to act, under certain conditions, as the new Board, were Messrs. Todhunter, Owen, Jones, and J. W. Daley, who formed part of the committee appointed at the last meeting.

Mr. TODHUNTER said the committee had conferred with the Directors, who came to the conclusion that it would be useless to ask the shareholders to go on and find further money if the original Directors remained in office. He spoke of the difficulty in getting gentlemen to act on the new Board, and added that it had therefore become necessary for them, on the part of their committee, to take up that position themselves. They would only, however, take office on the condition that the capital which was required was subscribed up to the hilt. If that capital were forthcoming he was inclined to believe that the Company would eventually prove a success, for he was firmly persuaded of the value of the process which they possessed.

General BEADEL severely censured the previous management of the Company, as did other shareholders. The following resolution was subsequently carried—

"*That this meeting be adjourned for fourteen days, and that, in the meantime, a circular be sent out showing the names of the gentlemen who are willing to take office as Directors provided 8,800 preference shares be in the meantime subscribed, and upon the understanding that if the shares are not fully subscribed any money paid on the same shall be repaid in full.*"

Western and Brazilian Telegraph Company (Limited).

The following is the report of the Directors to be presented at the twenty-fifth ordinary general meeting of the Company, to be held at Winchester House, Old Broad-street, E.C., on Thursday next, the 11th inst., at 12 noon:—

The total earnings for the half-year ended December 31, 1892, amount to £86,954. 11s 2d. as against £92.345. 4s. 7d., showing a decrease of £5.390. 13s. 5d. compared with the half-year to December 31, 1891. The working expenses amount to £37.165. 11s. 5d. as against £38,404. 5s. 1d., a decrease of £1.238. 13s. 8d. Including the amount brought forward from June 30, 1892 (£1,662. 5s. 3d.), and the dividend received upon the shares held in the "Platino" Company, the balance to the credit of the revenue account is £58,838. 5s., from which has been deducted £12,426 for debenture interest, and £6,674 for the debenture redemption fund, leaving £39,738. 5s., of which £15.000 has been placed to the reserve fund. The Directors now recommend the payment of a dividend of 4s. 6d. per share, free of income tax, for the half-year on the ordinary shares, making, with the dividend paid in November last, £2. 10s per cent. for the year, leaving a balance of £2,829. 15s. 6d. to be carried forward. In the case of shares which have been divided into "preferred" and "deferred," the 4s. 6d. per share now recommended will be payable to the "preferred" shareholders, making up the full dividend on the preferred shares for the year 1892.

The fourth annual drawing of the "A" and "B" debentures took place at the Company's offices on January 16th last in the presence of Mr. W. W. Venn, jun., notary, when debentures amounting to £13,300 were drawn, and have since been paid off at par.

The Company's new repairing steamer frequently referred to has left for her station on the coast of South America. The duplication of the cables over the greater part of the system renders it feasible, in the opinion of the Directors, satisfactorily to maintain the cables with only one repairing steamer, and consequently tentative measures are being taken with this object.

The new cable *viâ* French Senegambia was opened for traffic on October 5th last, and was in active competition with the old system from that date until December 27th, when it became interrupted. It was repaired on February 9th of this year. A further reduction in the tariff for messages exchanged with Brazil, Uruguay and the River Plate, came into operation on April 1st last.

The land line connecting Buenos Ayres with Valparaiso, regarding which the shareholders have already been informed, is approaching completion, and the Directors are given to understand will be in operation about the end of June next.

The dividend warrants will be posted on May 12, 1893.

The retiring Directors are Mr. W. S. Andrews and Mr. J. Coppen, who offer themselves for re-election. The auditors, Messrs. Turquand, Youngs, Weise, Bishop, and Clarke, and Messrs. Deloitte, Dever, Griffiths, and Co., retire and are eligible for re-election.

Yorkshire House-to-House Electricity Company (Limited).

The following is the report of the Directors, to be presented to the Ordinary General Meeting, to be held at the Central Electric Lighting Station, Whitehall-road, Leeds, on Friday next, May 12th, at 3 p.m.:—

The Directors submit a statement of the income and expenditure for the past year, and the balance-sheet showing the assets and liabilities of the Company made up to December 31st last. It is intended in future to make up the accounts to December 31st in each year. It will be seen that the balance at credit of the net revenue account is £11. 11s. 3d., which amount it is proposed to carry forward.

The plant for the first installation of the Company's works is now practically completed, and, it is expected, will be in operation at or before the date of the coming general meeting, when the Directors hope that a large number of the shareholders will avail themselves of the opportunity of inspecting it.

In response to applications from intending consumers, some extensions of mains have been carried out since the last general meeting, and the total length of culverts now laid is about 12.000 yards. In order to meet the urgent requirements of important customers, electricity has been supplied since December 14th last from temporary plant erected on part of the Company's spare ground. This supply has been maintained without interruption or irregularity, although the conditions under which it was

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generated were not so favourable as will be the case in running the permanent plant. The only drawback has been the impossibility of giving the supply to more than a very small proportion of the applicants. The applications for current already received are equivalent to about 10,000 lights. The demand is still growing at a very satisfactory rate, and will, it is anticipated, at an early date render it desirable to increase the capacity of the Company's plant.

The retiring Directors, Mr. Robert Hudson and Mr. Samuel Ingham, being eligible, offer themselves for re-election. Mr. John Gordon, jun., offers himself for re-election as Auditor.

NEW COMPANIES, STATUTORY RETURNS, &c.

[In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in "The Electrician" Electrical Trades' Directory and Handbook, 1893, pages 320-348, &c., &c.]

ALADDIN PRIMARY ELECTRIC BATTERY COMPANY (LIMITED).—This Company was registered on April 28th with a capital of £6,000 in £10 shares, to acquire the patent rights of Mr. Theophilus Coad in a primary battery and electric miners' safety lamp, also to acquire the secret for the manufacture, and the right to manufacture the fluid used in the battery, and to carry on the business of an electric-light, heat, and power supply company, and as electricians, mechanical, and electrical engineers, &c. The subscribers, with one share each, are:—T. Coad, Tottenham, electrician; A. Saunders, 21, Great St. Helens, E.C.; H. Bonner, 40, The Avenue, Gipsy Hill, S.E.; Percy M. Mountain, Hawtree, West Dulwich; Joseph Walton, 132, Christchurch-road, Tulse Hill; William Hope, High-street, Wimbledon; Henry S. Mountain, Selsdon-road, West Norwood. The first Directors are T. Coad, H. Bonner, P. M. Mountain, and A. Saunders.

ELECTRICITATS-GESELLSCHAFT GELNHAUSEN.—Under this title a limited liability company has just been formed, with a capital of 650,000 marks, to take over and carry on the business of the Gelnhausen branch of the Electriciteits-Maatschappy of Rotterdam. The new Company acquire the De Khotinsky patents for Germany, and will manufacture incandescent lamps, accumulators, and all kinds of electrical apparatus.

GEORGE HENDRY AND CO. (LIMITED).—Capital, £3,500 in £10 shares, as copper smiths, metal founders, and art metal workers, at Oat-lane, Church-row, Limehouse, London, E.

PERKINS AND BELLAMY (LIMITED).—This Company was registered on May 1st with a capital of £70,000, in 2,000 £6 per Cent. Cumulative Preference and 5,000 ordinary shares of £10 each, to carry on the business of agricultural and electrical engineers, contractors, &c., at Ross and Hereford.

RAINBOW ENGINEERING COMPANY (LIMITED).—This Company was registered on May 1st, with a capital of £20,000 in £5 shares, to carry on the business at Albany-buildings, Victoria-street, Westminster, S.W., of electricians, suppliers of electricity for the purposes of light, heat, motive power, or otherwise, and manufacturers of and dealers in all kinds of electrical and scientific apparatus.

ZOHRAB AND BIGGS ENGLISH PATENTS (LIMITED).—This Company was registered on May 1st, capital £32,007, in 3,200 deferred shares of £10 each and seven preferred shares of £1 each, to acquire certain letters patent granted to Messrs. Zohrab and Biggs for improvements in railway signalling.

CHELSEA ELECTRICITY SUPPLY COMPANY (LIMITED).—An agreement, made April 15th, between the Cadogan Electric Light Company (Limited), in liquidation, Arthur Greenwood (liquidator), William B. Peat (Receiver and manager), and the Chelsea Company states that, whereas the Cadogan Company is in liquidation, it was agreed that the Chelsea Company should purchase all the leasehold premises, stock-in-trade, plant, &c., the benefit of all contracts, and the sum of £250 lodged with the Metropolitan Board of Works, from the Cadogan Company for £10,250. The said sum is to satisfied as to £2,000 by the issue to the vendors or their nominees of second mortgage debentures of the value of £2,000, £5,000 by the allotment and issue to the vendors of 1,000 fully-paid ordinary shares of £5 each, and £3,250 by four acceptances of equal amounts payable at three, six, nine, and twelve months after the date of the completion of the purchase.

CITY OF BATH ELECTRIC LIGHTING AND ENGINEERING COMPANY (LIMITED).—The annual return of this Company, made up to March 25th, has been filed. Out of a nominal capital of £60,000, 5,500 ordinary shares, of £10 each, and 50 founders' shares of £100 each, 3,334 of the ordinary, and all the founders' shares have been taken up. 2,250 ordinary and the founders' shares have been issued as fully paid, and the full amount has been called on the remainder, resulting in the payment of £10,770.

DICK, KERR AND CO. (LIMITED).—The annual return of this Company, made up to April 12th, has been filed, showing that the whole nominal capital of £160,000, divided into 16,000 ordinary and 16,000 preference shares of £5 each has been taken up.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The annual return of this Company to April 7th has been filed. Out of the nominal capital of £95,000, divided into 13,000 ordinary and 6,000 preference shares of £5 each, 12,931 ordinary, and 6,000 preference shares have been taken up. Upon the preference shares the full amounts have been called, and upon the ordinary £4 per share, resulting in the payment of £81,724.

ELECTRICAL ENGINEERING COMPANY OF IRELAND (LIMITED).—A resolution was passed on March 24th, and confirmed on April 17th, that the Company be wound up.

ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY (LIMITED).—A petition for the compulsory winding up of this Company was presented on the 25th ult. by the Securities Insurance Corporation (Limited), and is down for hearing at the Royal Courts of Justice on May 17th.

FROUDE-HURRELL TORPEDO COMPANY (LIMITED).—Proofs of debts against this Company (in liquidation) must be sent in to Mr. C. J. Stewart, the liquidator, at 33, Carey-street, W.C., by the 13th inst.

JOHANNESBURG LIGHTING COMPANY (LIMITED).—The annual return of this Company to April 20th is filed, showing the nominal capital to be £150,000, in 50,000 preference and 100,000 ordinary shares of £1 each. 50,000 preference and 77,132 ordinary have been taken up, of which the preference and 77,125 ordinary were issued as fully paid in exchange for fully paid shares in the South African Company of the same name.

KESWICK ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to March 14th, has been filed. 3,420 £1 shares out of a total of 5,000 have been taken up, the full amount called, and all calls paid.

LEEDS AND LONDON ELECTRICAL ENGINEERING COMPANY (LIMITED).—The annual return of this Company, made up to January 2nd, has been filed. The nominal capital is £100,000, divided into 250 founders', 9,750 preference, and 10,000 ordinary shares of £5 each. All the founders', 734 preference, and 8 ordinary shares have been taken up. Upon the founders', 634 preference and 8 ordinary shares, the full amounts have been called, and upon the remaining 100 preference shares a call of £1 per share has been made. The calls paid amount to £4,530.

TAUNTON ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of this Company, made up to March 14th, has been filed. Out of a capital of £20,000, in £5 shares, 2,569 have been taken up, of which 787 have been issued as fully paid. Upon the remaining 1,782 the full amounts have been called, and all calls (£8,910) paid.

TELEPHONE COMPANY OF EGYPT (LIMITED).—This Company's annual return, made up to April 25th, is filed. The nominal capital is £100,000 in 16,000 preferred and 4,000 deferred shares of £5 each. 12,071 preferred and 4,000 deferred shares have been taken, and with the exception of 71 preferred, issued as fully paid. Upon the last-named shares the full amounts have been called, and all calls paid.

WOKING ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of this Company, made up to December 31st last, has been filed. The nominal capital is £20,000, in £5 shares, and 2,965 shares have been taken up. Of these 2,873 were issued as paid. Upon 20 shares 5s. per share has been called, upon 20 more 10s. per share, and upon the remaining 57 shares 25s. per share, resulting in the payment of £85.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended April 30th were £792, as against £794 for the corresponding period of last year, being a decrease of £2. The total receipts for the half-year amount to £15,360, against £14,096 in the corresponding period of 1892, being an increase of £1,264.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—A petition for confirming a resolution reducing the capital of the above Company from £307,545 to £234,938 has been presented to Her Majesty's High Court of Justice.

CONTINENTAL METROPOLITAN TRAMWAYS COMPANY (LIMITED).—At the meeting, recently held, of this Company Mr. B. H. Van Tromp (the Chairman) notified the shareholders that in Paris the Directors were trying to find some method of mechanical traction which they could economically adopt. A suggestion was under consideration for the use of a peculiarly constructed engine for their long lines, but at present he was unable to notify any progress in the matter.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of April are £3,900, as compared with £3,738 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY.—The gross receipts for the month of April were £1,742.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of April amounted to £56,469, and to £53,683 in the corresponding period of 1892, an increase of £2,786.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of the Eastern Extension, Australasia and China Telegraph Company (Limited) for the month of April, 1893, amounted to £41,713 and to £38,824 in the corresponding period, of 1892; increase, £2,889.

ELMORE'S GERMAN AND AUSTRO-HUNGARIAN METAL COMPANY (LIMITED).—A report of the proceedings at the second ordinary general meeting of this Company, held on Wednesday, will appear in our next issue.

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GREAT NORTHERN TELEGRAPH COMPANY.—7s. 2d. per £10 share, representing the final dividend for 1892, are now payable at the Company's bankers, Messrs. C. I. Hambro and Son, No. 70, Old Broad-street, London, E.C., against coupon No. 27.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED.—The traffic receipts for the week ended April 28, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,074.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Apr. 26.	Price Wednesday, May 3.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May 3. Highest	Lowest.
			TELEGRAPHS			£ s. d.			
£1,247,720	Stock	12/6	Anglo-American	52½ 53½	53 54	5 1 10	J n , Apr., July, Oct.	53½	53
£2,876,140	Stock	25/0	Do. Preferred	93 94	94 95	5 15 9	" "	95	93½
£2,876,140	Stock	5/0	Do. Deferred	12¾ 13½	13 13½	..	" "	13½	13
£250,000	100	4%	African Direct, Telegraph 4% Debentures	101 104	101 104	3 16 11	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	11¾ 12¼	11¾ 12¼	5 6 1	Mar., June, Oct., Dec.	12⅛	12
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	106 110	106 110	4 10 11	June and December	..	..
$7,716,000	$100	$13¾	Commercial Cable Capital Stock	140 150	140 150	4 13 4	April and October..	..	..
16,000	10	8/0	Cuba Submarine	11½ 12½	11½ 12½	6 8 0	February and August	12½	..
6,000	10	10/	Do. Preference 10%	18½ 19½	18½ 19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½ 3½	2½ 3½	4 11 5	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11¾ 12	11¾ 12	5 13 8	Jan., Apr., July, Oct.	12	11¾
400,000	10	2/6	Eastern	15½ 15¾	15½ 15½	4 3 10	" "	15½	15½
70,000	10	6%	Do. 6 per Cent. Preference	16½ 16¾	16¼ 17	3 10 7	" "	16⅝	16¼
£1,294,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock.. xd	114 117	114 115	3 9 7	May and November	114	113
£105,900	100	5%	Do. 5 per Cent. Debentures 1899	107 110	107 110	4 10 11	February & August	..	..
250,000	10	6/6	Eastern Extension xd and Bonus	15⅝ 15⅞	15½ 15¾	4 8 11	Jan., Apr., July, Oct.	15¾	15½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	113 116	113 116	3 9 0	February & August	114⅜	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	104 107	104 107	4 13 6	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	104	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101 104	101 104	3 16 11	February & August	..	..
180,227	10	2/3	Globe Telegraph and Trust	9½ 10	9¾ 10	4 12 6	Jan., Apr., July, Oct.	10	9¾
180,042	10	6%	Do. 6 per Cent. Preference	15⅝ 15⅞	15⅝ 15⅞	3 15 7	" "	15⅞	15⅝
150,000	10	5/0	Great Northern xd	19½ 19¾	19 19½	4 7 2	Jan., April, and July	19 9/16	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	103	..
17,000	25	12/6	Indo-European	43 46	43 46	5 8 8	May and November	46	44½
38,348	10	4/0	London Platino-Brazilian	4 6	4 6	6 13 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
10,802	8	4/0	Reuter's	7 8	7 8	..	April and October...	...	..
3,381	£100 Cert.	30.0	Submarine Cables Trust 6%	120 125	120 125	4 16 0	" "	..	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	100½	..
30,000	10	2/0	West Coast of America	2 3	2 3	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	100 104	93 102	7 16 10	June and December	...	..
88,321	10	6d.	West India and Panama	1½ 1¾	1½ 1¾	..	" "	1⅛	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	11½ 12¼	11½ 12	5 0 0	May and November	11⅝	11¾
4,669	10	6%	Do. 6 per Cent. 2nd Pref	9½ 10½	9½ 10¼	5 14 3	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	108 111	108 111	4 10 1	June and December	110¼	..
64,242	15	3/0	Western and Brazilian	7¾ 8½	7¾ 8½	5 9 1	May and November	8⅜	..
33,129	7½	3,0	Do 5 per Cent. Cumulative Preferred	6 6¼	6 6½	5 15 7	" "	6⅜	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1¾ 2¼	1¾ 2¼	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106 109	106 109	5 10 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106 109	106 109	5 10 1	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage xd	120 125	120 125	5 12 0	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	101 104	101 104	5 15 5	March & September	..	..
			TELEPHONES.						
40,000	£5	10/0	Chili Telephone (fully paid)	3 4	3 4	..	..	..	..
224,500	14/0	1½d.	Consolidated Telephone Const. & Maintenance	1/16 1/8	3/16 1/8	..	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	⅛ ¼	⅛ ¼	7 18 2	Yearly	..	..
454,747	5	2/6	National	5¼ 5⅜	5½ 5⅝	5 9 1	June and December	5 1/16	5 1/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref	15 15½	15 15½	3 17 6	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14½ 15	14⅜ 15¼	3 18 8	" "	15	14⅜
90,950	5	6⅜d.	Do. 5% Non-Cumulative 3rd Pref. (£3 paid)	5¼ 5⅜	5¼ 5⅜	..	..	5⅜	..
726 477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	113 116	113 116	3 17 7	January and July ..	115	114½
48,000	£10	..	New Telephone, Limited (£4 paid)	.. ..	.. ..	..	..	..	..
58,000	5	1/0	United River Plate	2 3	2 3	..	January and July ..	..	..
	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (fully paid)	12½ 12¾	12½ 12¾	..	—	12 9/16	12½
20,000	£10	..	Do. 6 per Cent. Preference (£4 paid)	10½ 11	10½ 11	..	..	11	10 11/16
18,000	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	—	—	—
£150,000	£5	..	Electricity Supply Company Ordinary	.. ..	.. ..	..	—	—	—
£47,909	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
8,332	£5	..	House to House Electric	.. ..	.. ..	..	—	—	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully pd.)	.. ..	.. ..	..	—	—	—
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	..	..	..
90,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4¼ 4½	4¼ 4½	..	January and July ..	..	..
10,000	£5	5/0 '92	Do. (fully paid)	6 6¼	6 6¼	..	..	..	..
111,000	5	..	London Electric Supply	1 1⅛	.. ..	..	..	..	..
43,900	£10	4/0	Metropolitan Electric Supply (fully paid) xd	6½ 7	6¼ 6¾	2 19 3	—	7	6 11/16
£50,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, & £40)	102 105	102 105	4 15 3	June and December	103⅞	103⅜
6,318	10	..	Notting Hill Electric Lighting (fully paid)	5 6	5 6	—	—	..	..
18,680	£5	9½%	St. James' and Pall Mall	7¾ 8¼	7¾ 8¼	..	—	8 1/16	7 15/16
7,900	£5	7%	Do. 7% Preference	7¾ 8¼	8 8¼	4 2 4	—	8 5/16	..
12,858	5	2/0	Westminster Electric Supply (fully paid)	5¾ 6	5½ 6	2 18 4	—	5¾	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/6	Brush Electrical Engineering	3¼ 3½	3¼ 3½	..	—	3 7/16	3⅜
99,996	2	6%	Do. 6 per Cent. Preference	2¼ 2½	2¼ 2½	4 6 0	—	2 7/16	2¼
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	109 111	109 111	4 3 4	..	110½	109½
20,000	5	5/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼ 5¾	5¼ 5¾	6 1 9	January and July ..	5¼	..
12,139	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	.. ..	..	—	..	..
45,000	10	12/0	Electric Construction	2½ 3	2½ 3	..	—	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	3/8 ½	¼ 3/8	—	—	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	—	1/16	..
50,000	10	15/0	India Rubber, Gutta Percha &c., Works	22 23	22½ 23½	5 6 4	February & August	23½	23¾
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½ 3½	2½ 3½	..	..	..	..
11,334	£10	8/0	Do. Preference	6 7	.. ..	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	5/0 6/0	5/0 6/0	..	..	..	..
78,949	5	4/2½	Swan United (£3. 10s. paid)	3 3½	3 3½	10 0 0	May and November	3½	3 1/16
37,350	12	24/0	Telegraph Construction and Maintenance	29 32	29 31	5 16 1	March and July...	29⅜	28
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	..	—	..	..
..	£5	..	Do. Preference (fully paid)	.. ..	.. ..	—	—	..	..
			RAILWAYS AND TRAMWAYS.						
63,000	£10	..	City and South London Railway	.. ..	.. ..	..	—	..	..
600,000	Stock	5%	Do. Stock	37 39	37 39	2 17 8	May and November	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 782.—Vol. XXXI. FRIDAY, MAY 12, 1893. PRICE FOURPENCE. *Annual Subscription (U.K.), 19/6*

NOTES.

Electrical exhibits at the Royal Society Conversazione were as numerous as usual, but no novelties of special interest were shown. Mr. Campbell Swinton showed his high-frequency experiments, and by running a five-candle 100-volt lamp through his body will—though he himself has done all that he can to correct it—encourage the idea that high-frequency currents produce small physiological effect. An interesting demonstration of the simple way in which these currents obey Ohm's law, was shown when Mr. Swinton took the current, probably a small fraction of a milliampere since he could hardly feel it, from hand to hand, and lighted the lamp. On bringing his hands together, the lamp became brighter, the resistance offered by his body being thus short-circuited. On separating his hands a little, sparks, which by their length showed the presence of thousands of volts, passed between them. Similarly, two or more persons may grasp hands, the lamp will be dimmed, and on short-circuiting any one of the experimenters, sparks will pass. The current in these experiments seem still to defy measurement. A comparison between the heating of two fine wires of different diameters might eliminate the skin effect, but the estimation of anything but the watts is surrounded with considerable difficulties. Among other matters of electrical interest were Major Holden's instruments, Mr. Callendar's thermometers, Rev. F. J. Smith's inductoscript figures, Sir David Salomons' photometer, which is fully described in another column, and last but not least, demonstrations by Lord Armstong, of the transference of a cotton thread, and of water currents under electrification, and of remarkable dust figures produced by spark discharges in air.

Mr. Swinton used about 20 amperes for his induction coil, taking the current from the mains supplying Burlington House. In another room Prof. Ewing was showing his curve tracer. The beautiful sweeps of those curves which have become associated with the name of Ewing, as the Japanese butterfly with the name of Whistler, were thrown on a screen, but every now and then threw themselves into wild contortions, wreaths of wriggles, and intricate sinuosities. These were due to the interruptions of the primary current of Mr. Swinton's coil, the mains being hardly large enough for both experiments at the same time. Scientifically, the curves were spoiled, but for conversazione purposes they were greatly improved; for at conversazioni something is wanted which shall be in the first place agreeable to look at, in the second place not self-evident, but in the third place, explicable in a few words. Organisers of such exhibitions, have a wide field open to them in the combination of totally different experiments.

Sir David Salomons and Mr. Pyke exhibited some pretty vacuum tubes and an alternator of an output of two million micro-amperes at a frequency of 262,800,000,000 per annum, and running with a relative speed of about 36,000,000 revolutions per week. It is not usual to describe alternators in this way, but as the exhibitors seem to have departed from the usual practice simply for the sake of big figures, we adopt their suggestion. A confused use of "alternation rapidity" instead of "frequency" is made for the sake of doubling the figure, and by taking alternations per minute instead of complete periods per second, as is the custom of all English engineers, the figure is increased 120-fold. As far as we can make it out the frequency is really only about 9,000. The Ewing-Parsons machine gives 14,000 complete periods per second, and Tesla used 13,000. Whatever it may be, no new phenomena seem to have resulted.

We are extremely glad to see that the Chairman of Ways and Means has given notice that he will to-day move the following:—

"Electric Powers (Protection clauses).—That a Joint Committee of Lords and Commons be appointed to consider and report whether the grant of statutory powers to use electricity ought to be qualified by any prohibition or restriction as to earth-return circuits, or by any provisions as to leakage, induction, or similar matters; and, if so, in what cases and under what conditions. And if the Joint Committee are of opinion that any such prohibition, restriction, or provision should be enforced, to settle the necessary clauses. That a message be sent to the Lords to communicate this resolution, and desire their concurrence."

We trust that no effort will be spared to present the case for electric traction in the clearest possible light. It should be borne in upon the Joint Committee that it is solely and wholly a question of Cheap Traction *v.* Bad Telephony. Those who are interested in electric traction will do well to remember that whatever decision the Joint Committee arrives at will have more or less of a finality character; and if they do not wish the decision to go against them by default, they must be up and doing now. It is expected that the Joint Committee will sit immediately after Whitsun.

The electrical industry in this country should take note that in Philadelphia the comfortable doctrine is being preached

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that "the People have a moral right to rapid transit." It would not be a bad stroke of business for the Electric Traction Association, now in process of incubation, to import the doctrine and the preacher thereof into this country. Were the public thoroughly imbued with this notion by a persuasive peripatetic orator, it would give a much-needed fillip to electric tramways, and act as a counterblast to the telephone protection clauses in existence or in contemplation. When once it is properly understood that there is no "greater injustice" than "to compel weary men and women, worn with the strain of a long day's work," to walk home, it will be obvious that there can be no greater injustice than to compel weary men and women to do a long day's work in stuffy rooms filled with gas fumes. This is, indeed, "a consummation devoutly to be wished," and it conjures up visions of the Beckton gasometers converted into cool storage tanks, and the palatial headquarters in Horseferry-road transformed into a home for decayed gasmen.

The movement in favour of the municipalisation of the telephones seems a veritable *deus ex machina*. No one is particularly satisfied, either from the engineering or the public point of view, with the present state of telephony in England. On the other hand, no one loves Government control if it can be avoided. A few weeks back we chronicled the fact that the Glasgow Corporation contemplated applying for a telephone licence, and now, as will be seen in our Notes column this week, Manchester appears to be tending to a like policy. The question arose over an application by the National Telephone Company for permission to run some of its wires under the streets, and Dr. John Hopkinson has been instructed to prepare a report upon the subject of underground telephone wires in general. From what passed at the meeting of the Town Council it would seem as if they meant to have all and every telephone wire placed underground. It is to be doubted whether there is any real need for such a drastic measure, and there can be no doubt that it would be unjust to compel a company to adopt so expensive a system without giving it a more secure tenure than is, perhaps, altogether advisable. Overhead telephone wires, as they are now being run in London neatly over the housetops and across the streets, in the majority of cases at a suitable angle, do not seriously offend the eye and are not a source of danger to the public. Inter-exchange cables, on the other hand, ought to be and are being everywhere put out of sight, or, as in the case of the hideous catenary which until recently threatened the traffic on the south side of Trafalgar Square, should be separated into a hardly visible band of fine wires.

Electrical measurements have of late years been tending to divide into distinct classes. One of these consists of measurements of precision, in which complicated and delicate apparatus can be employed, where time is but of little importance, where the "fifth figure" is a laudable aspiration, and where a set of instruments can sometimes be set up and kept for special work. The other extreme is the use of simple direct-reading instruments, of what may be called the switchboard class, to measure current and volts. The dials are, or should be, as legible as those of steam-gauges; an accuracy of one-half per cent. is claimed, and an accuracy of something better than one per cent. is commonly attained. But there is plenty of room for electrical measurements which fall between these two classes, such, for instance, as have to be made daily in the testing-room of an electrical factory or of a municipal authority. Laboratory instruments as well as laboratory methods are not well suited for such work. One-quarter per cent. must be attained, though an error of a-sixteenth of an inch in a two-foot rule exceeds this, and is more common than is generally imagined.

Calling the intermediate class of instruments testing-room instruments, these must be simple, direct-reading, easily read, always ready for use, and are all the more valuable if they are suitable for a variety of work. At such an instrument Mr. Crompton has been working for several years. The principle is old enough, and that is in itself, perhaps, a very considerable advantage. It is a potentiometer, but a very different affair to the slide-wire arrangement generally seen in laboratories. By successive improvements upon the form devised by Dr. Fleming, and by the use of manganin, a degree of accuracy has been arrived at which raises this apparatus to a high class, while it retains all the simplicity necessary for engineering use. A full description of a Crompton potentiometer suitable for verifying voltmeters to one-tenth of a volt, for testing meters to one part in 1,000, and for measuring from one milliampere to 5,000 amperes or more, will be found in another column. It will be seen that Mr. Crompton relies entirely on the Clark cell, and the severe tests to which this invaluable standard has been put during the last two years or so show that it is fully worthy of the confidence which he places in it. It is not possible in this article to give a complete description of the many ingenious details of construction of his instrument. The stretching devices, the rheostat, and the adjustment of the fourteen coils are all of great interest, and are the outcome of much careful work by Mr. Crompton himself in his private laboratory, resulting in a most useful and accurate instrument.

We have been requested to contradict the rumour, which has, we learn, obtained considerable credence, that the failure of the electric light in the precincts of the House of Commons on Monday evening last was caused by an impatient Cabinet Minister cutting short the debate by short-circuiting the main fuse with a bradawl. The following letter from the Secretary of the Westminster Electric Supply Corporation gives the true version of the incident. We may add that although 500 amperes were thus suddenly thrown off the plant without warning, nothing went wrong at the station :—

Sir,—With reference to the statement in many of this morning's papers to the effect that the extinction of the electric light at the House of Commons last evening is understood to be due to some failure in the supply furnished by an Electric Lighting Company, as secretary of the Lighting Company I beg to inform you that such extinction was not due to any failure or fault in this Corporation's supply, but was owing to the melting of a safety fuse in the House itself, over which the Corporation has no control. The Westminster Corporation has never failed in its supply since its first commencement.

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As a matter of fact, however, in these days of the "all-by-electricity" mania, a switch for turning the lights out whenever further debate became inconvenient, placed by the Premier's side, would be, as penny-a-liners say of wedding presents, both useful and appropriate.

At a well-attended dinner held at the Whitehall Club on Friday last, the proceedings being otherwise of a private character, the following telegram was sent:—

CLOWRY, Chicago, for ELISHA GRAY.

The Electrical Engineers of England, dining together at their Club to-night, desire to convey to their professional brethren in Chicago sincere congratulations upon the opening of their grand Exhibition. We hope to appear in person in August next to support the success of your magnificent undertaking. PREECE, Whitehall Club. May 5.

Whatever views may be held as to the utility of English firms exhibiting at Chicago, or whatever other opinions may be held about the Exhibition, this expression of friendly congratulation may be taken as representing English appreciation of the energy which has carried the enterprise through, notwithstanding many adverse circumstances and a general lack of enthusiasm outside the United States.

Wakefield.—The Town Council have decided to apply for an Electric Lighting Order.

Lord Kelvin.—It is announced that the Italian Minister of Public Instruction has nominated Lord Kelvin to be a member of the Academy of Naples.

Coventry.—Mr. Graff Baker hopes to have his electric cars running by August, and intends to start the electrical equipment of the line immediately.

Obituary.—We have to record the death, in his eightieth year, of Dr. Mathäus Hipp, which took place at Zurich on the 3rd inst. Dr. Hipp was one of the pioneers of electric telegraphy on the Continent, and invented a great number of electrical instruments and apparatus.

Owens College, Manchester.—At least two Bishop Berkeley Fellowships, of the value of £100 per annum, are offered for award in June next. Evidence must be presented of ability to prosecute some special study or research. A limited number of appointments to Honorary Research Fellowships will be made on the same date.

Halifax.—At the last meeting of the Town Council, the Gasworks Committee recommended that application should be made to the Local Government Board for sanction to a loan of £30,000 for electric light works, and that the electrical engineer should be instructed to prepare all the necessary plans, estimates, and specifications for the scheme. The minutes of the Committee were approved.

Electric Traction for Canal Work.—In a recent message to the New York Legislature, Governor Flower called attention to the possibilities of electric traction for the State Canals, referring especially to the use of the trolley system, and suggested the establishment of power-houses by the State at proper intervals. The Legislature has taken action on this recommendation by appropriating $12,000 to be spent in experiments.

The Central Institution.—The following extract from the annual report of the Dean to the Governors of the Institute may be of interest:—

The staff of the Central Institution still thinks that a more distinctive name would be of advantage to the Institution. Some remarks were made on this point in the report last year. It is hoped that it will not be considered presumptuous if it is suggested that such a title as the "City and Guilds School of Engineering and Technology" would be distinctive and comprehensive.

Testimonial to Prof. Garnett.—On Saturday evening last, in the Physical Lecture Theatre of the Durham College of Science, the artisans and others who attended the winter series of lectures delivered by Prof. Garnett on "The Pioneers of Electricity," presented him, for the use of the College, with two electrical measuring instruments, as a mark of their appreciation of his efforts for their instruction. Alderman W. H. Stephenson presided, and there was a large attendance.

Edinburgh.—It seems that by the constitution of the Edinburgh Town Council, a resolution of the Council does not become final until it has been three times affirmed by the councillors. On the first occasion, the figures in regard to the electric lighting scheme were: For, 20; against, 10. Last time they were: For, 19; against, 16, six members of the Council failing to record their votes. There undoubtedly exists a strong feeling against the proposal that the Corporation should themselves work the undertaking.

Ealing.—At the last meeting of the Local Board the Electric Lighting Committee reported that the plans of the proposed electric light buildings were before the Committee, together with the specifications for boilers, machinery, &c. The Committee came to the unanimous resolution to recommend that tenders for boilers and machinery should be invited forthwith, and that application should be made to the Local Government Board for permission to borrow £25,000. The Report of the Committee was adopted.

Hampstead Vestry.—At the last meeting of this Vestry, the Electric Lighting Committee recommended that the specifications prepared by Mr. Preece for the plant, &c., for the proposed central station should be adopted, and that the necessary advertisement for tenders should be inserted in certain newspapers. The Committee also asked to be authorised to take all necessary steps for carrying out the Hampstead Electric Lighting Provisional Order, and that application should be made to the County Council to advance to the Vestry the sum of £25,000. These recommendations were adopted.

The Telephone at Norwich.—The *Norfolk Standard* is pleased to be able to announce that a new Company has been formed, to be called the Norwich Telephone Company, the object of which is to supply subscribers with a cheaper and more efficient system. The new Company, which is of purely local origin, guarantees complete metallic circuits for £5 annually, for distances not exceeding a quarter-a-mile, £6 for under a half-mile, and £7 for a mile from the exchange. The Company is prepared to go to work as soon as 200 subscribers have been obtained. The new Company has, it is stated, no intention of allowing itself to be absorbed.

Bewdley.—At a recent meeting of the Town Council the Electric Lighting and Water Committee sensibly reported as follows:—Your Committee report that they have made further inquiry on the question of obtaining power from the Severn to supply Bewdley with electric light and for pumping purposes, and have pretty fully investigated one of the schemes proposed, which they think would probably prove successful. It is, however, an untried plan on any large scale; and your Committee are not prepared to recommend the heavy outlay necessary to prove its capability. They have other projects under consideration, and will report upon them in due time.

Electric Supply at Leeds.—The central station at Leeds was formally opened on Wednesday by the Mayor. The station has a capacity of 16,000 lights, of which 10,000 are said to be booked. The furthest lamp is at a distance of about three miles. As the Yorkshire House-to-House Company refused to give any particulars of the plant to our representative before the ceremony, we only received a brief account from him yesterday morning. The plant seems to be of the usual type employed in Mr. Hammond's undertakings, viz., Fowler engines, rope-driving, Lancashire boilers, and Lowrie-Parker alternators. Two 100-kilowatt and one 50-kilowatt machines are provided. Nalder voltmeters and vacuum tube earth testers are used.

Electrical Bills in Parliament.—On Monday the examiners in the House of Commons passed the Electric Lighting Provisional Orders (No. 3) Bill. In the case of the City of London Electric Lighting Company's petition for a Bill it was declared that the standing orders had not been complied with.—In the House of Lords the examiners passed the Brighton and Rotting-

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dean Seashore Electric Railway. On the same day the House of Lords read the Kensington and Knightsbridge Electric Lighting Company Bill a third time. On Friday last the Select Committee of the House of Lords appointed to inquire into the merits of the Bill promoted by the Dublin Southern District Tramway Company to empower them to acquire the lines of the Blackrock and Kingstown Tramway Company, and to use electrical power upon the entire system, ordered the Bill for a third reading.

Alternating Motors.—Alternating-current motors have, in the opinion of *Industries*, now very nearly been invented. There are many makers who are just bringing them out. For years there have been motors and rumours of motors, but so far there have been none really in the market. We do not know whether even now there are any stocked and sold on an ordinary commercial basis—that is to say, on the same footing as direct-current motors—but the number that are to be put on the market immediately has been increasing rapidly during the last few years. Of course, we are aware that double and triple-current motors have been in use for some time, and that very small and very large alternating motors have been used. The machines that have been so long on the point of bursting into commercial use are 1-H.P. to 10-H.P. single-current motors which start easily and take currents in proportion to their load.

Royal Institution.—At the general monthly meeting on Monday last the honorary secretary reported that the late Earl of Derby had bequeathed £2,000 to the Royal Institution. The special thanks of the members were returned for the following donation to the Fund for the Promotion of Experimental Research at low temperatures:—Mr. Alfred F. Yarrow, £50; Sir David Salomons, £50; Mr. Henry Vaughan, £20. —At the annual meeting of the Royal Institution, held on Monday last week, the annual report of the Committee of Visitors for the year 1892, testifying to the continued prosperity and efficient management of the Institution, was read and adopted. The real and funded property now amounts to above £104,000, entirely derived from the contributions and donations of the members and of others appreciating the value of the work of the Institution. Sixty-three new members were elected in 1892. The books and pamphlets presented in 1892 amounted to about 238 volumes, making, with volumes purchased by the managers, a total of 768 volumes added to the library in the year.

The Decimal System.—Messrs. Willans and Robinson have adopted the metric system in their works. They have taken this course owing to the practical convenience of the metric system and to their conviction that they thus obtain commercial advantages in securing orders in those countries where the metric system is in force, and in order that parts of engines made by them may be interchangeable with those made by their licencees abroad. We are authorised to state that their existing standard sizes of engines, chiefly used for non-condensing purposes, will remain unaltered, in order, among other reasons, to avoid causing inconvenience to present users of their engines, the gauges, templets, &c., only, for the sake of uniformity in the works, being restamped to the nearest hundredth of a millimetre. A new series of engines, however, specially designed for condensing work, which is now in hand, and all new works will be constructed to even measurements on the metric system. Mr. Charles Louis Hett, of the Turbine Foundry, Brigg, contemplates adopting this system of measurement in his works also.

Medical Battery Company v. "Science Siftings."—The Medical Battery Company have, says the *Electrical Review*, withdrawn proceedings against *Science Siftings*, and have paid £1,500 damages, including costs, on the counterclaim. "The ground of action will be better understood," says our contemporary, "if we refer to matters preceding our own lawsuits. It will be remembered that the solicitors of the Medical Battery Company issued some time ago a circular to the newsagents, which stated that if they sold copies of the *Electrical Review* and *Science Siftings* containing libels on their clients they would be held responsible. Practically, the effect of the circular was to prevent many newsagents selling the papers in question. The matter was felt to be serious by us, and we at once commenced proceedings against the Medical Battery Company. The Medical Battery Company replied to this by serving us with a writ for libel, *Science Siftings* being served in a similar manner. A counterclaim was inserted in the pleadings of *Science Siftings*, damages being claimed on similar grounds to ours. The result of our action against the Medical Battery Company must be still fresh in the minds of our readers, and they will be pleased to learn that *Science Siftings* has practically proved its case without going into Court."

The Telephone Question at Manchester.—At a recent meeting of the Town Council the minutes of the Paving, Sewering and Highways Committee stated that a letter on behalf of the National Telephone Company having been considered, the Town Clerk, City Surveyor and Dr. John Hopkinson had been instructed to prepare a joint report upon the subject of underground telephone wires. Mr. Southern said this was a subject of great importance, and required to be approached in a broader way than would be possible by leaving it to a single committee. It should not be considered merely on the initiative of a private company. There were various modes in which the telephonic service might be dealt with. It might be desirable to ask the Postmaster-General to establish a local exchange, or it might be advisable to adopt the same mode as was adopted with regard to the tramways; or, seeing there were two companies in the town, it might be wise to secure competition between them. As a means of having the matter fully considered, he should move as an amendment that the minutes be confirmed except the one relating to the underground telephone wires, and that a special committee be appointed to inquire into the system and report upon the expediency of placing telephone wires underground, and to procure for the citizens the best system at the lowest cost. The amendment was lost. Mr. Clay then moved an amendment that the minutes be confirmed, with the exception of the one relating to the telephone wires. He pointed out that when a report had been received from the paving department about the condition of the streets, Mr. Southern's proposal to form a special committee might come on. The amendment was carried.

Sir James Anderson.—Before the reading of Mr. W. B. Sayers's Paper at the Institution of Electrical Engineers last night, the President, Mr. W. H. Preece, referred to the death of Sir James Anderson in the following terms:—"My first task is, perhaps, one of the most unfortunate and disagreeable that a President of an Institution of this kind can possibly have to discharge. It is to allude to the effects which Time inflicts on all communities when his scythe sweeps round and about and amongst us. We have had to-night announced to us the death of three prominent members of this Institution, but there is one who has gone to his long rest that many of us knew intimately and knew well, and whose loss will be very severely felt by a very large class of the members of this Institution. I refer to Sir James Anderson. Sir James Anderson is a man whom I have known intimately for now nearly thirty years. As a man I have never met anybody who more obviously carried in his face the characteristic of pure manliness, and whether you met him as an officer on the bridge of a ship when he was a distinguished captain in the Cunard service; or whether you met him on that gigantic vessel the 'Great Eastern,' when he successfully laid the cables across the Atlantic; or whether you met him as a Director of the Company which he managed so well; or whether he appeared amongst us here, he was one of those men who, somehow or other, succeeded in winding himself round your heart, and you felt that in him you had a friend and a strong man. In addition to this he was essentially a gentleman, and I am sure those members of the Eastern Telegraph Company and all its associated companies who have acted in various capacities under him will say they could never wish to have a chief who looked after their interests, who carried their secrets, or who attended to their wants more honestly and faithfully than Sir James Anderson. The Council to-night have desired that a vote of condolence should be sent to his son as his representative, and I am quite sure I am only echoing the wishes of all the members of this Institution when I say they heartily join in doing this deed of sympathy and this act of reminiscence of the services we have received from Sir James Anderson."

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ELECTRICITY AS A MOTIVE POWER.*

BY ALBION T. SNELL.

(*Continued from page 739, Vol. XXX.*)

§ 10. Calculation of the Field Excitation.

(*a*) The following points have now been determined:—The size of armature, the gauge of wire, and the number of turns for its winding; the shape of field-magnets, and length of the winding space; the bore of polar cavity and the width of the poles; the magnetic flux and the densities in armature, gap, field cores and yokes.

The excitation necessary to give these fluxes and the corresponding winding have now to be calculated. The method adopted by the author does not take into direct consideration the permeability of the iron, although, of course, this is understood in the limiting values of B proposed. It is based on curves, see Plate I., connecting induction per square inch of core with ampere turns per linear inch of distance through which the induction has to be maintained. The principle of these curves was first suggested by the Hopkinsons in 1885. The co-ordinates are the mean values of the ascending and descending curves of the magnetisation. The variation of induction due to hysteresis is most marked with cast iron, but is of little importance with well annealed Swedish plates, such as are used for armature cores, especially if the induction be about B = 100,000. Therefore in practice no trouble is caused by hysteresis other than the loss of energy due to the cyclic change of magnetism, which is rendered evident by a development of heat. The calculation for this will be given further on.

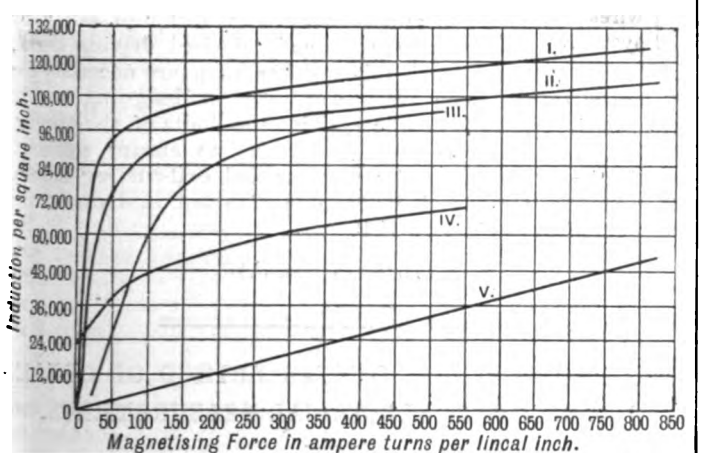

PLATE I.—Curves of Magnetic Induction in Iron and Air.

Scale of Ampere Turns for Iron: One division = 50 ampere turns per inch.
I. Annealed Swedish Charcoal Plates, as used for Armatures.
II. Wrought Iron Forgings, as used for Field Magnets.
III. Cast Steel, as used for Field Magnets.
IV. Cast Iron, as used for Field Magnets.
V. Air—To read Ampere Turns multiply abscissæ by 20.
All the Readings have been determined from the Mean of the Ascending and Descending Curves of Magnetisation.

In Plate I., Curve I. refers to annealed charcoal iron plates, from 22 to 24 B.W.G., the data are taken from experiments made by Mr. George Halliday.

Curve II. relates to magnet iron, large scrap hammered, allowed to cool slowly after forging. The values of the co-ordinates were originally taken from Dr. Hopkinson's paper on the characteristics of the dynamo; but they have been altered to suit the samples of iron used by the author, most of which have been supplied from Yorkshire forges.

Curve III. is taken from the recent experiments of Mr. Steinmetz with annealed cast steel, which is likely to be largely used for magnets.

Curve IV. is for the class of grey cast-iron generally supplied in London for magnets. The samples which have recently come under the author's notice have perhaps a slightly higher permeability than that implied in this curve. However, it is best to be on the safe side with cast iron, as the cooling so largely affects the results, and with these values there will be no doubt about the output of the machine.

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Curve V. shows the number of ampere turns required to send the induction through the gap. Its abscissæ are calculated from the equation

$$B''_g = \frac{AT}{0{\cdot}31328 \cdot \delta} \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

where $\delta = 1$ inch, and 0·31328 is a dimensional coefficient to convert the absolute measures into practical units, and also containing a factor to allow for the fringe of magnetism at the edges of the poles.

To use this curve find the ampere-turns corresponding to the density, and multiply by twice the length of the gap expressed in decimals of an inch.

(*b*) *Excitation for Open Circuit.*—The data must now be collected in order to make the calculations for the number of ampere-turns. It is necessary to know for the armature:—

B''_a = The induction per unit area.
$A_a 0{\cdot}85$ = The area of cross section less 15 per cent., which will be occupied by the insulating material between the plates.
m_a = Mean length of magnetic path in armature core.

For the gap:—

B''_g = The induction per unit area.
δ = Length of the air gap on one side.
A_g = Area of one of the polar cavities.

For the field-magnets:—

B''_f = The induction per unit area.
A_f = Area of core (wrought) in square inches.
A_{f1} = Area of yoke (cast) in square inches.
m_f = Mean length of magnetic path in cores and pole-pieces.
m_{f1} = Mean length of magnetic path in yoke.

Since the design is symmetrical about the perpendicular line *a b* (*see* Figs. 1 and 4), it is only necessary to measure the path of the lines of force around one-half of the circuit. The excitation thus determined refers to one limb only, and must be doubled to give the full number of ampere turns. This method is usually adopted because it both saves time and gives smaller figures.

The excitation for the several parts of the circuit is:—

Armature:—	$m_a f(B_a'')$.
Field cores:—	$m_f f(B_f'')$.
Field yoke:—	$m_{f1} f(B_{f1}'')$.
Gap:—	$2\,\delta f(B_g'')$.

And, summing up—

$$A.T_s = m_a f(B_a'') + m_f f(B_f'') + m_{f1} f(B_{f1}'') + 2\,\delta f(B_g''). \quad (12)$$

(*c*) *Excitation to be added at Full Load.*—In the preceding equation the demagnetising effect of the armature is neglected, and no allowance is made for the fall of potential over the internal resistance of the armature and series coils.

The demagnetising and cross-magnetising fields due to the armature have been already referred to, and it has been shown that these effects are most pronounced with the gramme type of armature. The subject has been exhaustively treated during the past two years, and need not be discussed in detail here. Suffice it to say, that the band of conductors lying between the pole tips will, as a whole, tend to produce a field in the opposite direction to that due to the main excitation; while the coils lying under the pole-pieces, *i.e.*, in the polar cavity, will tend to cause a cross magnetism. The latter is not of serious importance if the pole-pieces be very thin near the centre, as at *a* and *b* in Figs. 4 and 6. If, however, the pole-pieces be very massive in the region of the centre line there will be a cross field, which will have a tendency to twist the main field by crowding out some of the forward induction. But this can be almost entirely obviated with the relative proportions and shapes of magnets given in § 8.

The demagnetising turns are of more importance, and must be allowed for by an equal forward induction. The disturbance is, with gramme rings, proportional to the armature current multiplied into the number of turns included in the angle of lead; and this product must be multiplied by the coefficient of leakage between the field and armature, since a certain quantity of the field induction is lost in space.

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Therefore the compensating turns are

$$C.T_s = C_a \frac{2\theta}{360} i_a v = C_a \frac{\theta}{180} i_a v \quad . \quad . \quad (13)$$

where θ = the angle of lead in degrees.

With drum armatures the disturbance is about one-half as great, and so the compensating turns are

$$C.T_s = C_a \frac{\theta}{180^\circ} \frac{i_a v}{2} . \quad . \quad . \quad . \quad . \quad (14)$$

To find the turns to compensate for the fall of potential, it is necessary to make two calculations for the $A.T_s$, one with no current flowing in the main circuit, and hence no armature reactions, and one at full load. The former will determine the strength of the shunt coils if the machine be compound wound; and the latter will give the shunt excitation plus extra turns to be added for the fall of potential due to the internal resistance. The total excitation is :—

$A.T_s$ for open circuit + $C.T_s$ for demagnetising effects + $C.T_s$ for fall of potential.

Practically, with large gramme rings the two last quantities will be about one-third of the first.

If the machine be shunt wound the winding must be determined at full load, and the $C.T_s$ must be added before calculating the gauge of wire.

The same remark also applies to a series machine.

A few trial windings will soon illustrate the point, and facility will come with experience.

§ 11. Special Points to be observed in designing Motors.

So far the author has considered the design of either dynamo or motor simply from the point of view of the total E.M.F. of the armature, and has given no special attention to the torque. But it was mentioned in § 2 that in designing motors it was essential to give due weight to both the maximum and average couples likely to obtain. The importance of this will be best seen from an inspection of the equation for the torque in terms of the armature constants :—

$$\text{Torque} = T = \frac{C_a i_a}{2} \cdot \frac{N_a}{K}, \quad . \quad . \quad . \quad . \quad . \quad (15)$$

or the torque is directly proportional to the product of the number of turns of wire, the magnetic flux, and half the armature current. K is simply a dimensional coefficient. The numerical value of K is $852{\cdot}3 \times 10^6$, if T be in pound feet, so that adopting the practical unit

$$T = \frac{C_a i_a N_a}{852{\cdot}3 \times 10^6} \text{ pound feet.} \quad . \quad . \quad . \quad (16)$$

Now, in all ordinary motors the number of turns of wire in the armature, C_a, is constant, and only the current i_a, and the magnetic flux N_a vary. There are two simple cases for consideration in practice. First, when both i_a and N_a vary; this occurs with a series-wound motor, and it should be noticed that a relatively small increment of current may cause a considerable increase in the value of the torque, for the magnetism will be greatly varied at the straight part of the characteristic with low values of B, and therefore N_a will at this point increase much more rapidly than i_a; whilst after the knee of the curve is passed the rate of increase of N_a for increments of i_a will slowly decrease, until a point is reached where the torque simply varies with the current.

The second case is where N_a is constant, and i_a alone varies. This condition is given with a shunt-wound motor, if it be assumed that the armature reactions are negligible. The torque, therefore, will simply vary with the armature current; it will be a minimum with small loads, but will finally attain the same maximum value as it would if the motor were series-wound. Both of these windings give special advantages to a motor, and hence they are severally selected for particular work. The compound-wound motor is a combination of the two schemes, and has not met with much favour as yet. The uses of the three types of windings will be more fully discussed further on.

It remains now to investigate the best lines for building armatures for special turning-moments.

If the desired brake horse-power and the speed of the motor be known, the work per revolution and the torque can be easily determined.

The work per revolution in foot pounds

$$= \frac{\text{B.H.P. } 33000}{n} \text{ foot pounds} \quad . \quad . \quad . \quad (17)$$

and the torque $T = \frac{\text{B.H.P. } 33000}{2\pi n}$ pound feet, . . . (18)

n = revolutions per minute.

It should be noticed that T is independent of the diameter of the armature.

The peripheral pull exerted by the armature

$$= \frac{\text{B.H.P. } 33000}{2\pi n} \cdot \frac{1}{g} \text{ pounds} \quad . \quad . \quad . \quad (19)$$

where g = the radius of the armature in feet.

This force will act tangentially on the winding, *practically* at two parts diametrically opposite each other, and just underneath the leading horns of the pole-pieces. If the value represented by B.H.P. be the average load, we can thus determine the average strain on the wire; and if it equal the maximum output the maximum *running* torque is known. But suppose the current to fluctuate largely, and at times to exceed the current corresponding to the maximum current output; at starting, for example, the momentary rush of current may easily be twice or even three times as great. Then, from what has been said, it is clear that the torque will be increased also and it may be sufficiently to endanger the stability of the winding, or even to bend the shaft. Therefore, in motors it is usual to allow a very large factor of safety by supporting the winding by specially devised driving horns, and by the use of much stiffer shafts than are necessary for dynamos of the same average output. In designing motors, then, it is advisable first to examine the limits of the turning couple, and then to take precautions to ensure sufficient mechanical strength. For tramcar and coal-cutting motors it is usual to provide shafts from 2½in. to 3in. in diameter for outputs of from 15 to 20 H.P.

(To be continued.)

CROMPTON'S POTENTIOMETER METHOD OF OBTAINING ACCURATE ELECTRICAL MEASUREMENTS.

To meet the requirements of Municipal authorities, standardising laboratories, manufacturing engineers, and others who desire to have a complete system of electrical measuring apparatus capable of making electrical measurements to a high degree of accuracy, Messrs. Cromptons have during the last six years been engaged in perfecting what is known as the potentiometer method.

As is well known, this method consists in reducing any of the three electrical quantities which are to be measured to the form of electrical pressure, or E.M.F., so that it can be compared by means of a potentiometer with a standard pressure such as that of the Clark cell.

The potentiometer itself is shown diagrammatically in Fig. 1. It consists of a wire A B stretched over a frame. Up to quite recently this wire was made of an alloy of platinum and iridium made as hard as possible to reduce wear. It was necessary to take great pains to ensure that this alloy was well mixed, and that the wire was accurately drawn in order that the electrical resistance per unit of length might be constant. The instrument is used in the following manner:—A constant current is maintained in the wire A B from one or more secondary cells of sufficient size to keep it fairly constant for three or four days' working. A variable resistance or rheostat is introduced in series with the cell and wire, arranged so as to adjust this current to give a certain difference of potential at the two ends of the wire. The circuit which includes the E.M.F. to be measured is connected at one end to one terminal, A, of the slide wire, and through a galvanometer to a sliding saddle C,

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which carries a knife edge to make contact on the wire A B at any desired point of its length. This circuit is so coupled up that the E.M.F. to be measured is opposed to the E.M.F. in the portion of the slide wire A C, in order that the position of C on the slide wire can be adjusted until the two E.M.F.'s balance one another so that no current passes through the galvanometer. In order to compare the E.M.F. to be measured with the standard E.M.F., a Clark cell is put in in circuit with the galvanometer, and the position of the slide C is noted when the above-mentioned balance has been obtained. The electrical pressure or E.M.F., required to be compared is then substituted for the Clark cell, and a similar balance found by adjusting the slider C a second time. Then the comparison between the two E.M.F.'s can be made by comparing the respective lengths of the slide wire included between the points A and C in the first and second case. By dividing the slide wire A B into a suitable number of parts, and adjusting the variable resistance until the galvanometer comes to zero when the Clark cell is in circuit and the contact C is at a point on the scale corresponding to the temperature value of the Clark cell, say 1·434 at 15°C., the instrument becomes direct reading in volts or fractions of volts.

The apparatus forming such a set consists of—1. A set of standard Clark cells; 2. The comparing instrument which is called the potentiometer; 3. A set of fractional resistances which can be used to reduce the pressures to be measured to that which can be conveniently compared by the potentiometer.

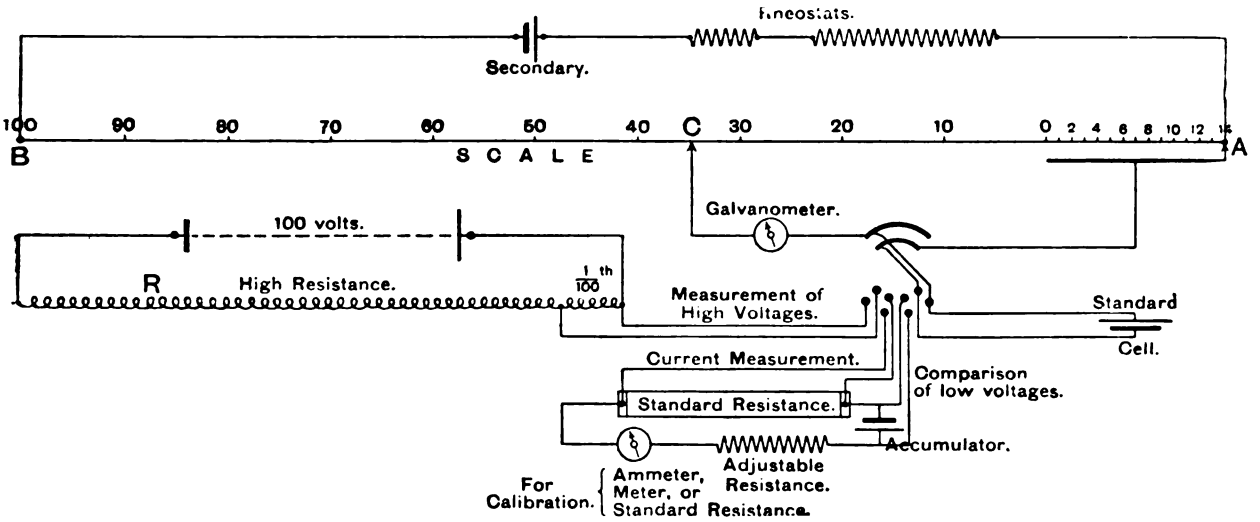

FIG. 1.

Dr. Fleming in the year 1883 first called Mr. Crompton's attention to the advantages of this system of measuring. Since that time the system has been steadily developed, and successive refinements have been introduced into the various instruments which will now be described. As the following description will apply to a set of instruments such as are suitable for a municipal standardising laboratory, it is here necessary to specify what are the requirements and limits of accuracy within which these instruments may be reasonably expected to measure. First, comes the verification of voltmeters. This is of importance on account of the disputes that are likely to arise as to the pressure supplied from electric-lighting stations. Voltmeters for standard pressures of 50 to 100 and 110 volts, are principally used for noting the pressures in the consumers' houses, and for such cases it is desirable that their readings at about the standard pressure should be verified to one-tenth of a volt or within one part in 1,000. Next it should be possible to verify and certify the constant of the various kinds of meters by which the electrical supply is measured to the consumers. These also ought to be verified to one part in 1,000. Next comes the verification of ordinary ammeters or current instruments used for trade purposes to about the same degree of accuracy. In both these last cases the range through which instruments would have to be compared is very considerable; for instance, the instruments sent for verification may be those used for testing electric lamps or for telegraphic purposes, measuring currents of one milliampere, up to those used for metallurgical or electrolytic purposes up to 5,000 amperes, or more.

The correct comparison of resistance standards as well as the correctness of the ratios of resistance boxes ought to be capable of verification to one part in 10,000.

In the comparison of resistances must be included the testing of the conductivity of various metals and the insulation resistance of various insulating materials.

The latest form of potentiometer which we now describe and illustrate has a scale 25in. long divided into 1,000 parts. The standard wire stretched over this scale is one-fifteenth part of the whole wire, therefore each division on the scale being one-fortieth of an inch repesents one fifteen-thousandth of the pressure at the two ends of the wire; in other words, if, as is generally the case, the instrument is standarised to 1·5 volts at the terminals of its wire, each division of the scale represents one ten-thousandth part of the volt.

In the first form of instrument proposed by Dr. Fleming, the potentiometer wire was made of an alloy of platino-iridium four metres long and had a resistance of about 20 ohms. The wire was divided into two parts and stretched over a scale; the whole of the wire, being required for measuring purposes, had to be carefully calibrated, that is to say its electrical resistance made equal per unit length throughout its entire length. This was a very tedious and expensive process. It was found very difficult, if not impossible, to obtain wire as it finally left the drawplate which was sufficiently homogeneous to be used without further adjustment. In most cases the whole of the wire had to be carefully scraped or rubbed until the required equality of resistance was obtained. Such a wire was very valuable, and if it was broken or accidentally melted, its loss was a serious matter.

In their latest form of instrument (Fig. 2) Messrs. Cromptons have abandoned the use of this expensive material, and at the same time have arranged so that only one-fifteenth part of the wire A B is stretched over the scale and subject to the wear of working. A B in the drawing shows this portion of the wire 25in. long, stretched over a scale divided into 1,000 parts. The resistance of this wire is usually about 2 ohms, and the remaining wire is divided into 14 coils, each of about 2 ohms, so that the R of the whole is 30 ohms. These coils are naked spirals, the terminals of which are fixed to the underside of the 14 contact blocks shown at E. The swinging arm shown can make contact with any one of these blocks. It is an easy matter to adjust these 14 coils when the instrument is first made so that their R will accurately equal one another, and the resistance of the working wire A B can then be adjusted by slightly stretching it until it is also exactly equal to any of them. As the 14 coils are protected they never need further adjustment, but if in the course of time the exposed portion of the wire A B becomes worn or is in any way damaged, a new piece of wire can be substituted in a few minutes and stretched, by means of the

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stretching screw shown at F, until its resistance over the portion from 0 to 100 exactly balances that of any one of the 14 coils. C is the sliding saddle carrying the contact. This consists of an ebonite box with dovetailed slides arranged to slide smoothly on the scale. It is provided with a knife-edge spring contact so that the contact must be made with a regular pressure which is independent of the pressure of the hand of the user; it also has a micrometer adjustment for accurate work. The semi-circular switch G and the cylindrical rheostat G 1 shown to the left, form part of the variable resistances above described and which are required to reduce the difference of potential between the terminals of the wire to any desired value. The value that has

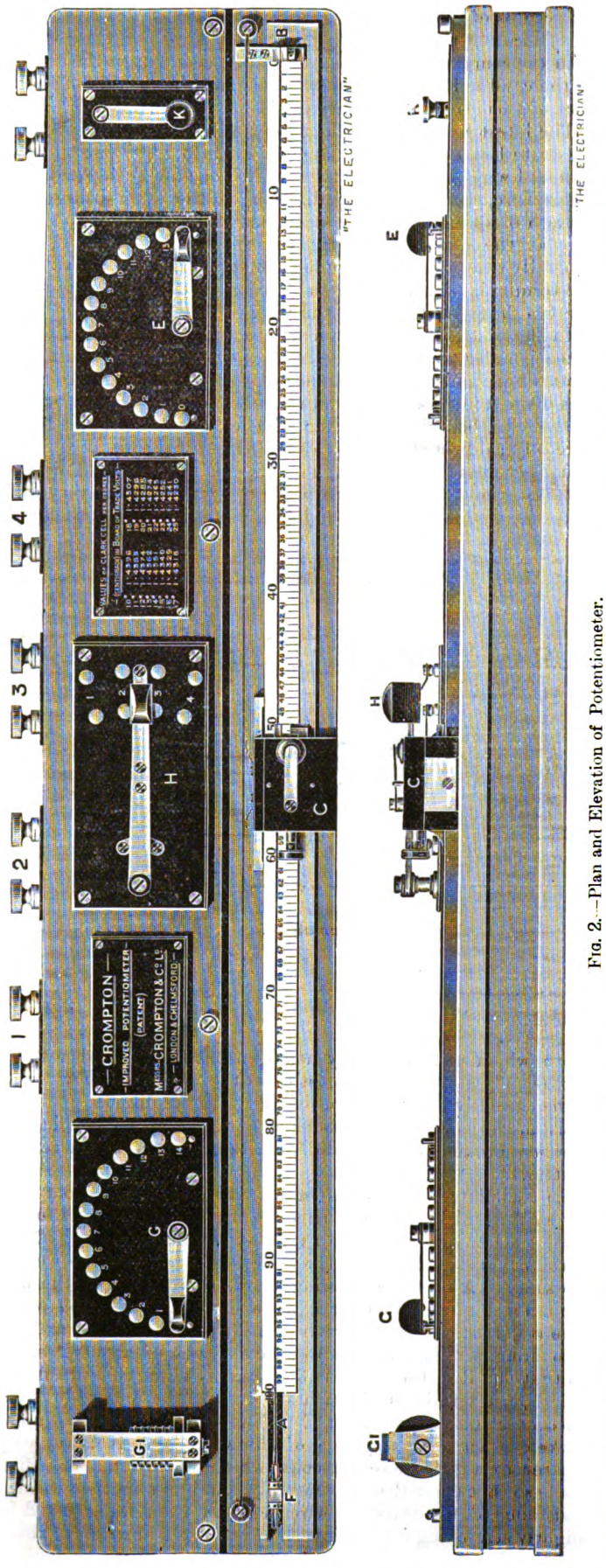

Fig. 2.—Plan and Elevation of Potentiometer.

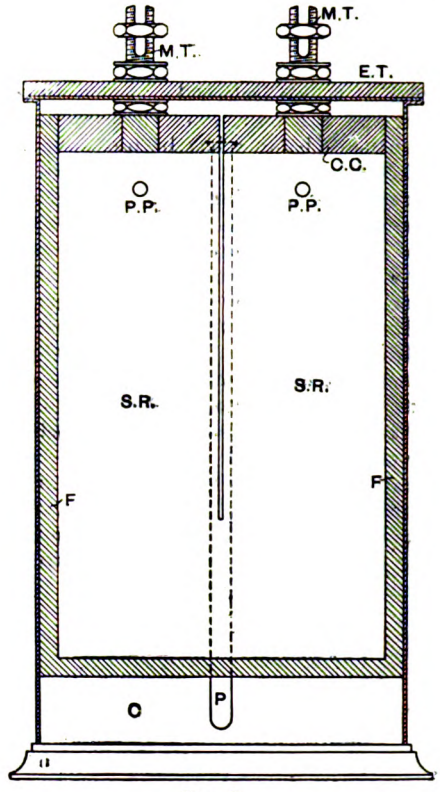

Fig. 3.

M.T., Main Terminals; C.C., Copper Clamps; P.P., Potential Points; S.R., Standard Resistance; F., Frame (Insulation); C., Case; P., Pipes; E.T. Ebonite Top.

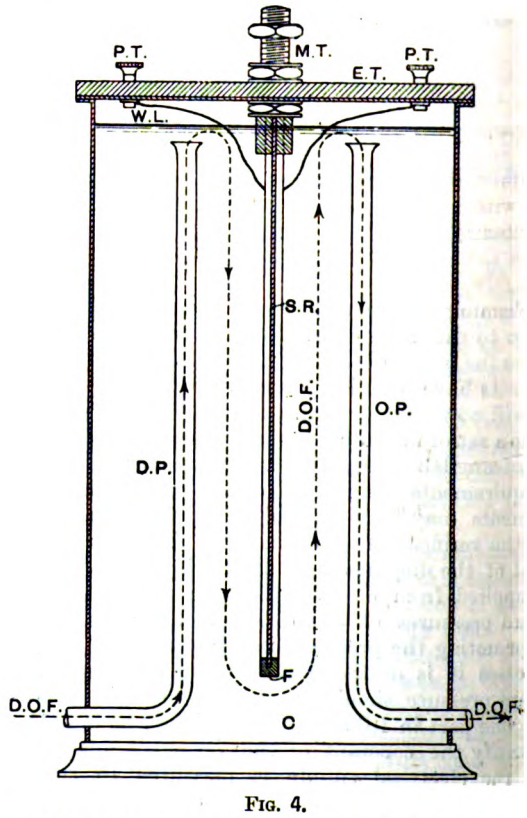

Fig. 4.

P.T., Potential Terminals; D.P., Delivery Pipe; O.P., Outlet Pipe; D.O.F., Direction of Flow of Water; W.L., Water Level.

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been chosen in this instrument is 1·5 volts. In order to obtain this, one small accumulator cell is connected to the left hand pair of terminals, and the resistances attached to G and G 1 are adjusted until when the knife-edge contact is put down at the value of the Clark cell, say at 15° C., 1434, the galvanometer comes to zero. In the present instance this reading is obtained by putting the swinging arm E on to the 14th block, and putting down the knife edge of C at 34 on the scale. When such a balance is obtained every one of the scale divisions will be equal to one ten-thousandth of a volt. The instrument is provided with 4 pairs of terminals, 1, 2, 3, 4. A Clark cell can be put on to one of these, and any three other electrical pressures to be measured can be connected on to the others. The switching arrangement H shown in the centre brings the galvanometer into series circuit with any one of these pairs of terminals. The contact key K shown to the extreme right is used for short-circuiting the galvanometer.

The fractional resistances for the measurement of high voltages shown at R in Fig. 1, require no special mention further than that, whenever it is required to measure an electrical pressure greater than that on the terminals of the potentiometer, that is to say in this case greater than 1·5 volts, the pressure to be measured is applied to certain terminals of a resistance box, and the terminals of the potentiometer are connected to other terminals on this box which include between them a resistance which is an even part, say, one-tenth, one-hundredth, or one-thousandth of the entire resistance of the box.

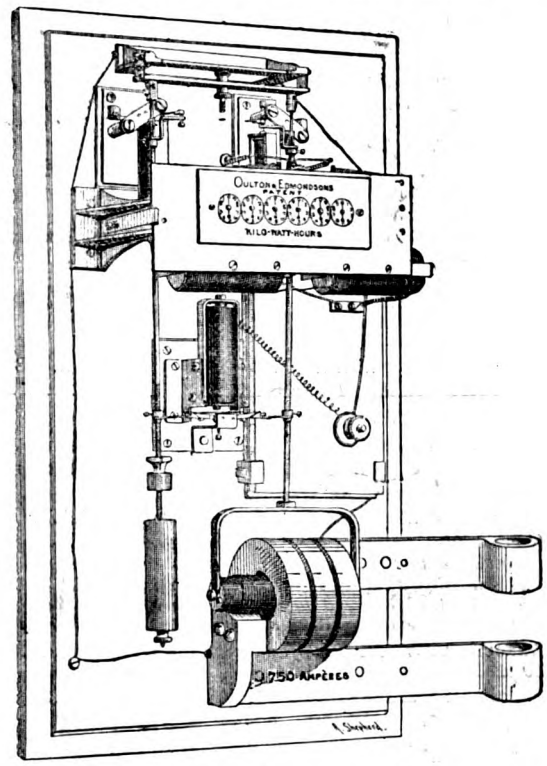
When, however, the potentiometer is employed for measuring currents, this is done by measuring the difference of pressure at two points on standard resistances which, in order to make the instrument direct-reading, must be either one ohm, one-tenth, one-hundredth, or one-thousandth, and so on. As these low resistances have to carry very high currents, they have to be designed so that they do not heat to a sufficient extent to introduce errors.

Figs. 3 and 4 represent a form of water-cooled resistance which has given excellent results. This consists of a cylindrical vessel made of brass into which a resistance made of manganin sheet S R is made in such a manner as to form a diaphragm dividing it into two parts. This manganin sheet is carefully protected by an insulating material and the cylinder is filled with water, and the circulation is provided by means of the pipes P. The water circulates down one side and up the other side of the diaphragm and its temperature is thus easily prevented from rising to a sufficient extent to alter the resistance of the manganin sheet to the extent of one part in 10,000. The manganin sheet is provided with massive copper terminals as shown, the terminals of the potential leads being taken off at the point P P. A resistance that is capable of measuring currents up to 2,000 or even 3,000 amperes is easily contained in a cylinder about 10in. diameter by 18in. high.

THE OULTON-EDMONDSON METER.

The ingenious and highly-promising meter which was brought out under this title some years ago offered several improvements over the Aron meter, of which it was a modification. There was a single clock movement, and two slow-torsion pendulums. As in the meter which we described last week, but by an independent invention, a gravity impulse arrangement has been introduced to drive the pendulums, instead of a clock escapement. A small-impulse arm which is not clearly visible in the illustration, acts upon a cranked arm projecting from the pendulum. The impulse arm is lifted by an electro-magnet, and is allowed to drop on the pendulum at the right moment. The lifting electro-magnet is controlled by the pendulum. All friction is thus eliminated, and excellent time-keeping qualities are ensured. A difficulty in such meters has been the synchronism of the two pendulums when no current is passing. Dr. Aron has hung a small weight on a very slack thread, which was sufficient, when there was only a small tendency to vibrate at different periods, to keep the pendulums in unison. In the present meter a device is introduced for the same purpose. It will be noticed that the pendulums are hung from a bar which is suspended by stiff springs. This bar receives an extremely small horizontal motion which is sufficient to keep the pendulums in unison, unless a certain definite force is exerted to make the meter work in the usual way by recording the difference between the number of beats of the two pendulums. As in the meter which we described last week, a catch arrangement is provided for stopping the meter. When no current is passing, a magnet, shown in the middle illustration, affects this by means of two hooks, which engage with the pendulums when they are swinging inwards. The hooks themselves make a path for the current, and by short circuiting a resistance, cause the initial current which starts the meter to be rather larger than normal.

It appears, however, from the description which has been sent us, that it is only when the meter is cut off altogether from the supply that the pendulums are stopped. To be of value, the stopping should be determined by the cessation of the main current. An important feature of the original Oulton-Edmondson meter is retained in this one; the two currents passing through the main coil and the volt coil would not, *by themselves*, give proportional readings, for the force required to produce the vibrations of a pendulum is in proportion to the square of the number of vibrations.



Upon each volt coil, therefore, there is wound a "correcting coil," carrying a very small proportion of the current passing into consumption. This small current makes the reading proportional throughout any range. The sparking at the contacts of the impulse gear is prevented by the use of a condenser and a resistance.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, May 12th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1) "The Drawing of Curves from their Curvature," by C. V. Boys, F.R.S. (2) "The Foundations of Dynamics," by Dr. Oliver Lodge, F.R.S.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Isoperimetrical Problems," by Lord Kelvin, P.R.S.

TUESDAY, May 16th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read and discussed: "Wreck-raising in the River Thames," by C. J. More, M.Inst.C.E. At this meeting the final ballot for members for the session, and the last of the present series of receptions by the President and Council, will take place.

WEDNESDAY, May 17th.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Ordinary Meeting at the Institution of Civil Engineers.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Composite Heliochromy," by F. E. Ives.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m Meeting at 20, Hanover-square, W. Exhibition with the Projection Microscope, by Sir David Salomons.

THURSDAY, May 18th.

CHEMICAL SOCIETY.

8 p.m. Paper to be read: "Observations on the Production of Ozone during Electric Discharge through Oxygen," by W. A. Shenstone and M. Priest.

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SPECIAL NOTICE.

With this issue of "THE ELECTRICIAN" is published a Steel-Plate Portrait of the Late SIR JAMES ANDERSON.

Complaints of non-receipt should be at once sent to the Publisher.

STEEL-PLATE PORTRAITS

Of Willoughby Smith; W. H. Preece, F.R.S. (President of the Institution of Electrical Engineers); Michael Faraday; Sir John Pender, G.C.M.G., M.P.; Sir William Thomson, F.R.S. (Lord Kelvin); C. H. B. Patey, C.B.; Dr. John Hopkinson, F.R.S.; Dr. Oliver J. Lodge, F.R.S.; Prof. William Crookes, F.R.S.; Prof. von Helmholtz; Prof. W. E. Ayrton; Lord Rayleigh, F.R.S.; Cyrus W. Field; Werner von Siemens; and Sir James Anderson, have been issued as Supplements to "THE ELECTRICIAN."

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THE PUPIL SYSTEM.

One of the avowed aims of technical education is to radically modify the old "premium pupil" system, and one or two recent cases in the law courts will also do something towards furthering that object. Some eighteen months ago we recorded, and commented upon, a case in which £120 damages were awarded to a pupil's parent owing to failure on the part of an electrical engineering firm to *instruct* the aforesaid pupil, who had paid a premium of £150. In the action *Cridlan and another* v. *Marler and Bennett* reported in *The Times* of Tuesday, exactly the same point was at issue, and exactly the same decision, this time with £125 damages, was arrived at. The complaint was that the pupil, who had paid £200 premium and bound himself for three years, had been kept for half that time at mere routine work and drudgery, no opportunity being given him to learn the technique of the business, which was that of auctioneer and house-agent, and no attempt being made to instruct him. The defendants replied that the ordinary custom was followed, and that "they could not always be at their pupils' elbows and delivering lectures to them." Large sums of money ought not to be taken, and as a matter of fact are not taken by firms of standing, without it is thoroughly understood that the sole *quid pro quo* is merely the opportunity of "picking up" practical knowledge; and if the pupil has had a good grounding in science at school or college, and is able and willing to learn, there is no call for animadversion. It is the practice of taking on an unlimited

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throng of raw youths and exacting heavy premiums from unsuspecting parents that we are glad to see exposed in the law courts. In the case of *Cridlan* v. *Marler and Bennett*, there was no question of bad faith but of difference of opinion as to what was a fair return for a large premium. The pupil seems to have been engaged in learning the useful but not intellectual work of an office-boy. The jury settled the dispute, and the judge remarked that it was a very delicate question and he was very glad that he had not got to decide it himself. In the other case to which we have alluded, it was proved that only seven or eight workmen were employed and about sixty-five premium pupils were taken; the pupils, in fact, were simply made use of as a particularly cheap, if not high-class, kind of labour.

The old system of indentures of apprenticeship promises to die out, like the old trade guilds. The modern agreements are far less formal, and the ancient customs and laws which defined the relations of an apprentice to his master can hardly be said to apply to them. Most engineering firms who take pupils will confess, if pressed, that they do not pretend to teach, or to do much more than give facilities for learning the practical work of the different departments. When the course was spread over five or seven years there was time to take in the practical details and reflect on the principles which underlie them, and to develop some of that instinct which was so characteristic of the engineer of the old school. A pupil who comes to a factory having an elementary acquaintance with mechanical science has only to keep his eyes open to learn how the principles are applied. At the same time he acquires a knowledge of the use of tools, which is necessary for the proper appreciation of good workmanship, and is the only way of becoming intimately acquainted with machine construction. The tendency to shorten the course to less than two years is to be regretted. Two years may be enough for a smattering in each department, but it is hardly long enough to give a chance of seeing a considerable variety of work. A firm specialising in one or two particular lines may offer little or no variety, one year's work being like that of another; but such firms should be avoided; even if the pupils really receive instruction they will be fitted for only one particular branch. Every year shows that the tendency to specialise is becoming more pronounced, and, no doubt, there are many cases in which a lad is compelled to begin to earn a living at the earliest possible date. But this should not affect the general character of the training of those who wish to enter so important a profession as that of electrical engineering. We are inclined to doubt whether most lads, even after going through a year or so of scientific study, are capable of making a well-considered selection of electrical engineering as their future profession. Medical men do not enter for their "first M. B." with the distinct aim of becoming specialists in some particular line; the selection, if made intelligently, must be made after the qualifying training has been completed. An intelligent desire to become an engineer is easy to understand; but before he knows anything of engineering how can a student choose a special branch, unless tempted to do so by the popular cry that electrical engineering is in its infancy and is the "coming thing?"

The ideal course is two years of science (real science not "technical education"), after which a choice between mechanical and civil engineering may be made; two or three years at a large general engineering works, if mechanical engineering be selected, and then one or two years at electrical works if electrical engineering be finally chosen. Partly because the necessity for preliminary scientific training has arisen, and partly because many lads have no opportunity for such an ideal course, technical education is offered, and tends, as we have said, to radically modify the apprentice system. Technical education can do nothing but teach principles; it cannot give a training in a profession, for it can give no practical professional experience worth mentioning. Pupilage in works, on the other hand, can seldom do more than offer free opportunity of picking up practical experience; it can give no actual teaching worth mentioning. The free run, or even a run under rules and restrictions, of a large factory is a most valuable privilege, and is well worth a handsome premium. Pupils are, however, as a rule, an unmitigated nuisance, and engineering firms are justified, we think, in raising their premiums to five hundred guineas if a few pupils will insist on paying it. Considering the work they may spoil, the dicipline they may disturb, the information about prices and standard designs which they may pick up, and the possibility of their setting up on their own account in direct competition with their late masters, the one hundred pounds a year which many electrical firms ask is little enough—from the masters' point of view,—for the pupils, *caveat emptor*. Though some decline them at any price, there are still plenty of first-rate firms who will take pupils. Because advertisements or circulars may mislead, the system need not be blamed.

The results which are likely to accrue, if the system of pupilage at works is abandoned or seriously cut down, are well illustrated in the remarks made by Sir Benjamin Baker at a discussion at the Institution of Civil Engineers. These remarks, which we print elsewhere, were made by a man whom no one can for a moment charge with contempt of theory, and one whose works have been the outcome of most arduous calculation. The practice of mechanical and of civil engineering is well established on a sure foundation of half a century of experience, and a careful engineer will consult previous cases as a guide for intended works. In electrical engineeering the ten years of its history affords but little solid experience of this kind. A few facts are occasionally collected into a Paper which is read before some society, and there gets picked to pieces by rival firms or theorists. The enquiring student after spending the day in a foundry or at the vice, comes to learn, and goes away unable to say what "the practice" is in connection with the subject he has heard discussed. No wonder that he seeks an apparently sure guide in the formulæ with which he filled his note books in his lecture-room days. Amongst other matter of great interest and importance in Dr. W. Anderson's "Forrest Lecture," of which we commence an abstract in another column, some observations will be found on the training of young engineers. He, too, while dwelling on the value of a preliminary scientific training, does not lose sight of the practical training which is so essential to the qualifications of an engineer. He recognises that there is a tendency for the pendulum to swing the other way, and for the rising generation of engineers to wax conceited and to imagine that scientific study will enable them to commence professional work at once, without going through the practical training which is afforded by the system of pupilage or apprenticeship.

The technical college and the workshop being, as we have pointed out above, complements the one of the other, it will be a matter for grave regret if any more of our leading firms, (at whose works alone proper training can be acquired), with the danger of adverse legal decisions superadded to the general nuisance of pupils, should come to the conclusion that the game is not worth the candle and decline to take in pupils at any price. The best course in the interests of the industry would be to insist on a precise agreement, setting forth in plain English that the firm does not pretend, and does not intend, to teach.

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SIR JAMES ANDERSON.

We deeply regret to record the death of Sir James Anderson, which took place at his residence in London on Sunday last, the 7th inst., after an illness of nearly three months' duration.

Sir James Anderson was born at Dumfries in 1824, and joined the Merchant Navy at the age of sixteen. In 1851 he entered the service of the Cunard Company, and commanded some of their best ships. He was a successful captain and navigator.

When the Telegraph Construction and Maintenance Company was formed for the purpose of laying the second Atlantic cable, the first having been irretrievably lost, the "Great Eastern" steamship was chartered to do the work, and it became a question as to who should command that ship. The then Chairman, Mr. (now Sir John) Pender wrote to Mr. McIver, the manager of the Cunard Company, asking him to grant the Company the loan of one of their best and most efficient captains. Mr. McIver kindly consented, and named Captain Anderson. This was his introduction to the Submarine Telegraph System, then in its earliest stage.

In the first voyage of the "Great Eastern," the cable parted, and Captain Anderson attempted to pick it up. He found, however, that the machinery at his disposal was not equal to the work, but felt confident that with proper appliances he could pick up the cable from the great depths of the Atlantic.

On the return of the ship Captain Anderson so impressed the Directors of the Telegraph Construction Company with his views, that they individually largely subscribed to the necessary capital, and the Board determined not only that the ship should be sent out to recover the cable that was lost, but also that a second cable should be laid, if they could find the amount of money necessary to enable them to have one manufactured. In both of these projects they were entirely successful. The ship went to sea under Captain Anderson's command, laid the new cable, and picked up the cable broken the previous year. For carrying out this important operation Captain Anderson received the honour of knighthood.

The fact that cables could be picked up from such great depths and repaired gave a wonderful impulse to submarine telegraphy. Sir James Anderson saw that there was a great future for it, and from that time he identified himself with the small band of men, led by Sir John Pender, who have been the real pioneers of submarine telegraphy, and who have carried out that great system which now extends to all parts of the civilised world.

At the time of his death Sir James Anderson was Managing Director of the Eastern Telegraph Company, the Eastern and South African Telegraph Company, and the West African Telegraph Company; he was Chairman of the Brazilian Submarine and Direct Spanish Telegraph Companies, and a Director of the Anglo-American, the African Direct, the Eastern Extension and the West India and Panama Telegraph Companies, and a Trustee of the Globe Telegraph and Trust Company. He was also a Director of the Metropolitan Electric Supply Company.

Sir James Anderson had a strong literary tendency, and was a member of the Statistical Society, before whom he read a Paper on "Statistics of Telegraphy," afterwards publishing a treatise under the same title which is regarded as a text-book on the subject. He was the author of important Papers on "Cables in Time of War," "The Government Purchase of Submarine Cables and Reduction of Telegraph Rates," "The Telegraphic Communication of the Empire and a Comparison of the Various Routes to the East." Sir James took part in the International Telegraph Conferences at Rome, St. Petersburg, London, Berlin, and Paris, and long advocated an "Authorised Vocabulary" from which the words used in code messages should be taken. It was due to his efforts in this direction that the last Conference decided to compile an official list of words, which is nearing completion. Sir James was a J.P. for Dumfrieshire, F.R.G.S., F.G.S., F.S.S., and received many distinctions from foreign Sovereigns, including those of Italy, Spain, Greece, and Turkey.

In all matters affecting the well-being of the staff of the Telegraph Companies in all parts of the world he always evinced a deep interest, and one of his latest acts was to support the establishment of a staff pension fund, the success of which has now been established; and its formation by Sir John Pender and Sir James Anderson will be long remembered with gratitude.

Sir James Anderson also took an active interest in *The Electrician*, of which he was one of the proprietors.

It can be said of Sir James Anderson that he endeared himself to all who came in contact with him. Endowed with a large measure of sterling common sense, of genial presence, possessed of the utmost kindness of heart, and availing himself of unnumbered opportunities of doing good to many besides those who had the honour of serving under him, he will be long remembered with very sincere affection and respect.

> "Whatever record leap to light,
> He never shall be shamed."

Almost his last public appearance was to take the chair at a dinner in aid of the Royal Alfred Home for Aged Seamen, on which occasion an unusually large sum of money was, through his exertions, subscribed. His name was greatly respected in the City, and his colleagues, with whom most harmonious relations prevailed, feel that they and the great cause of submarine telegraphy have sustained a severe loss, his intimate knowledge of the great cable network and his unique experience making him a most valuable colleague.

Sir James was twice married, and leaves one son, Mr. Kenneth Lockwood Morrison Anderson. Lady Anderson pre-deceased him in September, 1891.

On Tuesday last a funeral service took place at St. Philip's Church, Earl's Court-road, S.W., kindly lent for the occasion by the vicar, the Rev. W. Smale, M.A., who conducted the service, assisted by the Rev. Calmont Gallacher. A most impressive address was delivered by the Rev. H. W. Webb-Peploe, M.A. Many very old friends of the deceased were present, as were also the representatives of all the Telegraph and Cable Companies and the General Post Office. The coffin was covered with beautiful wreaths, and upon it was fixed a piece of the 1865 cable, in the recovery of which Sir James took so active a part.

The interment took place at Dumfries yesterday (Thursday). After a funeral service at Park House by the Rev. Mr. Chapman, at which a great number of Sir James's friends in Scotland were present, the body was removed to St. Mary's Churchyard, and the last rites were performed by the Rev. Mr. Paton. All the chief residents of the town and district were present at the graveside.

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Yours very truly
James Anderson

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THE INTERDEPENDENCE OF ABSTRACT SCIENCE AND ENGINEERING.*

BY WILLIAM ANDERSON, F.R.S.

Before commencing the task which has been imposed upon me by our Secretary, I think it will be well to explain the origin of the "James Forrest Lectureship."

During the Session of 1889 the Council of the Institution determined to have a portrait of Mr. Forrest painted with the view of presenting it to the Institution. An excellent likeness was produced by Mr. Wm. M. Palin, and it was presented at the ordinary meeting of November 11, 1890. As soon as the members had seen the portrait a large number expressed a wish to have an engraving of it; a committee was formed outside the Council, funds were rapidly collected, and an excellent engraving, by Mr. James Faed, was produced and distributed, while the surplus fund, amounting to about £500, was placed at the disposal of the Secretary, who determined that it should be devoted to the establishment of a "James Forrest Lectureship," and that it should be administered by the governing body of the Institution for the time being, who would select the lecturer and determine the subject of his discourse.

This is the first lecture under the Trust. The high and undeserved honour of delivering it was imposed on me; I accepted the task with much hesitation and misgiving, being deeply conscious that I was incompetent to do justice to the occasion.

The theme which has been prescribed is "The Interdependence of Abstract Science and Engineering," and I imagine that the subject has been chosen because of an uneasy feeling which possesses many thoughtful men that this country is not keeping pace with its neighbours in engineering progress, and that we shall, in the future, have to pay more attention to abstract science and its application to practice than we have been, so far, in the habit of doing, if we are to come out victorious from the competition, ever increasing in keenness, which we meet with from abroad, and which our system of unrestricted trade tends so much to foster. It is impossible to visit the Continent of Europe, the United States of America, or even our own Colonies, without feeling conscious that, in many respects, their engineering works and their factories, to say nothing of their military and naval arsenals, exhibit the great advantages which have accrued from the employment of men of the highest scientific culture in the conduct of those enterprises—that the days are past when an engineer can acquit himself respectably by the aid of mother-wit alone, or of certain constructive instincts, which have been almost the only guides of engineers and manufacturers, even down to quite recent times.

This Institution has already shown, in the regulations not very long established with respect to the qualifications of the student class, that it is alive to the fact that some scientific training is desirable in a profession in which the lives of human beings, to say nothing of their property, are dependent on the knowledge and skill possessed; that in the vast works now undertaken a great deal more than intuition is necessary, and that scientific knowledge and training are attributes which the public have a right to demand of its engineers. So strongly does this feeling exist that it has assumed practical expression in the form of Science Colleges, which have been founded, either by individual liberality or by subscription, in every considerable town in the provinces, completely eclipsing London where the movement first began but where it languishes for want of adequate support, except, indeed, in the noble endowments of the City and Guilds schools, and the Government establishments at South Kensington.

The old arrangement must come to an end; we must not be deceived by our past experience, when, supported by our immense and exceptional natural advantages, it may be admitted that our rough system worked fairly well.

In those days, and the practice survives even now, a public schoolboy was taken into an engineer's office or into a factory, and there he exchanged his small store of dead languages for an equally slender equipment in science, acquired as it best could be while following the routine of his master's practice, the said master being himself but scantily provided with anything more tangible than experience, an endowment which, from its very nature, is incapable of being communicated fully and which can only be acquired by the professional activity of a lifetime.

It has often been my good fortune to discuss with Continental engineers the relative advantages of the English and foreign systems of training. The foreign engineer had, as a rule, an admiration for what he called our practical methods, and lamented that in his own country training was almost exclusively theoretical; but I think that the superior education of the operatives abroad was not sufficiently recognised—the managers, the foremen, the draughtsmen, and even to a great extent the mechanics and other operatives, had had the advantage of technical training even before they began to acquire mechanical dexterity, so that the want of practical knowledge of the leaders has been met by a fair amount of theoretical knowledge engrafted on the practical experience of the followers, and it is incontestible that this combination is producing results as advantageous to our foreign competitors as it is disastrous to our own industries.

With rare exceptions, in this country, has there been even a slender amount of theoretical knowledge imparted to the various grades of employment; it is only during the last few years that Science Colleges and technical education in schools and People's Palaces, are beginning to bring our operatives up to the level of our foreign friends, but, unfortunately, too late to retain that pre-eminence which we at one time could claim, and, I fear, placed too much confidence in; and, morever, a new danger has arisen in the circumstance that popular scientific education has taken a one-sided direction—that of mechanical or technical knowledge alone—so that, though the operative approaches his work with increased intelligence, he remains unfit to reason out the great economic problems on which his own welfare and that of the nation depend.

It is a matter of extreme surprise to me that so little attention is paid to the science of Political Economy, that not only the mass of the people, in whose hands the voting power now lies, but even, in a great measure, the representatives whom they elect have no systematic training in, and are grossly ignorant of, the principles which lie at the root of national prosperity. The further misfortune follows that politicians of the highest position do not scruple to trade on this ignorance, or to pursue a course which, in its consequences, is as bad—being ignorant themselves they strive to lead the ignorant, and set the operative against his employer and against society in general. The cheapness of newspapers, their wide diffusion, and their blind, not to say reckless, advocacy of popular fallacies acting on the ignorance, prejudices, and discomfort, if not suffering, of the operative classes are giving enormous power to trade organisations whose avowed object it is to improve the earnings and social standing of the operative at the expense of, or at any rate without regard to, the interests of every other class in the community; and this is to be accomplished not by encouraging education, not by advocating thrift and temperance, not by urging the workman to improve his mechanical dexterity, the thoroughness of his work and the amount which he produces, but by holding out visions of shortened hours of labour, by compelling a minimum of pay which will enable him to live in comfort, of systematically restricting the amount of work done by each individual, even in the shortened day, all under the fatal illusion that by such means a greater number of men will find more remunerative employment.

The employer is usually credited by the trade leaders with accumulating wealth without effort, risk, or anxiety by the slavish labour of his operatives, while the proofs to the contrary, so easily to be obtained in the slender dividends declared by most industrial enterprises and in the records of the Bankruptcy Courts, are steadily kept out of view.

There would be no fault to find with the new class of professional agitators, who live by the discontent which they foment, were they, and the Unions which they manipulate, to contribute in the smallest degree to the obtaining of that work and of those orders in the execution of which the wage-earning portion of the community have their being. This, the most difficult part of every commercial enterprise, is left to the much-abused capitalist, so that the absurd and impossible system is fast asserting itself, that professional skill, mercantile ability and capital shall obtain the work and run all the risks of design, execution and financial security; but that work shall be carried out according to rules which self-constituted and perfectly irresponsible bodies choose to impose. The smallest acquaintance wfth the principles of political economy would demonstrate that such methods must end in ruin; that they are utterly incompatible with our policy of Free Trade—a system which is perfectly reasonable and proper thoroughly carried out, and which certainly never contemplated the protection of one particular class, and that, not by edict of the State but at the bidding of self-constituted tribunals whose claims amount to this:—that there shall be free trade in all products which the operatives require to buy, but the strictest protection as to all that they have to sell, namely their labour, and whose ultimate methods are violence and the coercion of all who differ from views which many intelligent but timid workmen know to be at variance with the true interests of their class.

Under all this lies the socialistic idea of equality in the condition of every member of the commuity, an idea which Political Economy demonstrates to be utterly Utopian and impossible. Since the creation of mankind, the differences in social position and in material comfort which follow naturally from the endless variations of mental and bodily powers in men have existed, and in spite of many abortive attempts, more or less violent, to establish equality, will exist for ever.

However much we may regret the inequality which exists in the distribution of wealth and comfort, it is just as much a law of

* Abstract of the "James Forrest" Lecture, delivered before the Institution of Civil Engineers, May 4, 1893.

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Nature as the unequal distribution of warmth, of sunshine, or of rain, and seems to me to follow naturally and inevitably from the endless variations in the physical, moral, and mental powers of human beings, and, therefore, to be as unalterable at the bidding of man as these attributes are. It only remains for us to recognise the fact, to make the best of it, and to avoid the gross wickedness of attempting to delude the poorer and more ignorant members of the community by incessant representations that it is the greed and selfishness of the wealthy which keep them low.

If the so-called "working man" be the embodiment of all that is needed for the industrial prosperity of a country, and if the possession of capital and the far wider consequence, the existence of credit, be a crime, why does he not arise in his strength and exhibit the faculties of combination which are so well illustrated in the trades unions, and establish engineering works and manufactories, or undertake engineering enterprises from which he will be able himself to reap the golden harvest which the capitalist and the shareholder are supposed to gather, and who thereby excite his envy and arouse his hatred? The reason is very obvious.

Saturday night comes with unfailing regularity, and the week's wages must be met; work has to be found, usually at prices to be calculated beforehand, and when obtained, contracts do not always go on smoothly; engines and machines will not always work; accidents will happen; long credits must be given; and those men who possess the talent and education to originate and the skill to administer are comparatively very few, even in this land of enterprise, and have their value which it is too much to expect that they will not take advantage of; while the buildings, machinery, stock and floating money which form the capital—of the true nature of which such terrible ignorance exists—are absolutely valueless without the skill and the industry necessary to obtain remunerative employment; while the matter of credit, on which so large an amount of our activity depends, is almost a personal matter, and could never be commanded by a body of operatives, however respectable.

In deference, I presume, to the immense numerical importance of the operative classes, politicians are vieing with each other in supporting the impossible claims put forth—claims which, if conceded, will only precipitate the ruin of the class they profess to benefit, and which already, in the form of what may be termed benevolent legislation in favour of the operative, is heaping up elements of cost which our productive energy is unable to bear. The absurd cry that manual labour is the sole source of wealth has been well combated by that acute reasoner, Mr. Macfarlane Gray, who, in a recent discussion on the labour question, happily compared the body politic to a tree. The popular belief is that plants are nourished through their roots, which for that reason are believed to be the all-important parts, while the leaves are mere ornaments, enjoying the upper air and sunshine and profiting by the work done underground. But a juster knowledge, one of the fruits of abstract investigation, tells us that the roots are mainly useful in holding the tree erect, and have comparatively little to do with providing the materials for building up its structure. It is the leaves which form the great laboratory in which the main components of the plant are extracted from the region where superficial observers would least expect to find them—namely, from the atmosphere. He compares the roots to the operatives' part of the community; the trunk and leaves to the monetary, the scientific and the commercial part which drew from far and wide that which is necessary to keep the growth advancing and maintain it in health. The roots may just as well claim to be the sole sources of life in the tree as the operatives may claim to be the only producers of wealth; and, conversely, the leaves could, with as much reason, consider themselves as the only essential portion of the plant as the merchant or the capitalist claim to be independent of the operatives. Each grade in the body politic is essential to the other; it is an axiom that there can be no degrees of comparison between essential parts; and those who, from ignorance or from interested motives, persistently preach the doctrine of the superior importance of the "masses" over the "classes" are inflicting a deep injury on the prosperity of the country, and especially on those whom they so grossly flatter.

It seems to me that a very great national danger is being incurred by this systematic neglect of Political Economy—an abstract science which had its origin in this country, but where its teachings are ignored in a manner which must end in disaster, the signs of the advent of which are, I fear, only too plainly apparent.

Even in my lifetime a great change has come over the methods of executing engineering work. During my apprenticeship in Manchester I was associated with workmen—millwrights they were called—perfectly uneducated, but of the utmost intelligence—men whose workboxes contained the tools of nearly every trade, and who could handle those tools with dexterity and skill. Before the days of easy communication they were sent away to great distances in charge of works, both extensive and intricate, and executed them, as a rule, with a thoroughness and an intelligence which left nothing to desire. The necessities of the present age have rendered great subdivision of work inevitable, so that there are but few mechanics left who are conversant with many trades, or whose characters and experience enable them to be as self-contained and trustworthy as the millwright of old; hence it seems to me hopeless to expect that, in the engineering trades at any rate, the workmen will ever be able to dispense with the commercially-educated and experienced capitalist and the highly-trained scientific staff he finds it necessary to employ.

And let it not be supposed that this, and kindred institutions, have no interest in the question. Our prosperity rests upon the well-being of our members, and that again depends upon the activity of trade and upon the existence of enterprise. But the "dividend-grabbers," as investors in industrial enterprises are elegantly called by the foolish and ignorant men by whom the operatives are content to be led, will not embark their money in ventures where there is no prospect of reasonable interest, or where the hopes of such interest are endangered by labour agitations, encouraged, to a great and fatal extent, by political parties, who do not scruple to purchase votes by holding out all kinds of Utopian prospects.

But money must be invested; it cannot, in these days, be hoarded in strong boxes, as it was in Pepys's time; consequently our capitalists will search for outlets abroad, and, by promoting industrial undertakings outside our shores, will, through the action of free trade, beat down the value of produce still more, and so further arrest the development of that manufacturing and engineering enterprise upon which prosperity depends.

One method of combating this, I have pointed out, is the dissemination of sounder views on Political Economy concurrently with the spread of technical education. The other course is to pay more attention to abstract science and to devote more time to the study of what is going on around us in the world. I am afraid that the nature of the education of the wealthier classes in this country is responsible for a good deal of the insular conceit and exclusiveness with which, in spite of our peripatetic tendencies, we are still afflicted. Classical education, no doubt, has its merits, and is well suited to a large section of the community; but in these days of the extensive scientific knowledge which a competent engineer is bound to acquire, the universal application of the method seems to be a mistake, while I cannot but think that the acquisition of modern languages and scientific study are fully as efficient in training the minds of the young as they are incomparably more useful in the battle of life afterwards.

Nor am I singular in this view. Successive Presidents of this Institution, in their inaugural addresses, have dwelt upon the cardinal importance of the education question, and within the last two or three years the Council has exacted conditions as to liberal education and scientific training from the candidates for student membership, which cannot be regarded as otherwise than happy; and without doubt, before very long, even in the higher grades of membership, evidence will be demanded of special attainments in abstract science which are now so accessible to all in every part of the kingdom. I do not for a moment lose sight of the practical training, which I consider so essential to the qualifications of an accomplished engineer. I recognise the fact that there is a tendency in the pendulum of knowledge to swing to the opposite extreme, and of the rising generation of engineers to wax conceited and to imagine that the diplomas obtained at Universities are guarantees of fitness to commence professional work at once. And here, again, I am in accord with many Past-Presidents, who, in their addresses, have dwelt on the importance of practical training. I hold that the engineer's education should begin earlier, even at school, and should embrace those branches of knowledge which in our great public schools are still in a great measure ignored or taught in a half-hearted manner, more as a concession to the utilitarian spirit of the age than as an essential equipment for many professions.

But nothing, save bitter experience, will alter the course of events. It seems to be the fate of peoples to attack social problems from the wrong end, to solve them by the painful and dilatory process of trial and error, rather than by means of investigation based on first principles. And this method is commonly applied to engineering problems also. Random trials, as a rule, are the methods by which great results have been achieved, while the application of the scientific principles involved have been left to other heads long after the results sought have been attained at much needless cost, and by much unnecessary expenditure of labour and of time.

(To be continued.)

A Projected Very Long-Distance Telephone Line.—The Automatic Telephone Company of Canada, which has just been incorporated, proposes, it is said, to run a telephone trunk line from Halifax to Vancouver, a distance of 3,500 miles.

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THEORY AND PRACTICE.

The following extract from Sir Benjamin Baker's remarks in the discussion on Graving Docks at the Institution of Civil Engineers, deserves the fullest publicity :—

"Bearing upon the general question of the value of theoretical investigations of strength, in cases such as a flat concrete invert, as compared with direct practical experience, he might say that several cases recently had made him a little nervous as to whether the results of the high technical training of the present day with many young engineers did not lead to a dangerous confidence in theoretical deductions and the use of formulas. No one could charge him with contempt of theory ; but cases had been brought under his notice rather frequently of late showing too great confidence on the part of young engineers in theoretical deductions, in preference to going to the same extent as their predecessors had been in the habit of doing to previous examples, in order to see what was the right proportion to adopt in a particular work. Only a few days ago a young engineer at a judicial inquiry attacked the stability of a work, not because it had shown any sign of failure or weakness, but simply because the theory from which he calculated its strength led him to think that the work should have failed. He did not seem to see that if his theory was at variance with practical observation he ought to revise his theory, and make it fit in with the facts. On the theory advanced, the work must have failed unless the tensile strength of green brickwork in mortar was such that a rope could be constructed of that material which would carry its own weight hanging vertically for a height of 220 feet. That consequence did not strike the young theoretician as at all absurd. Another case was one from the Antipodes, and that was really so good that he would like to read out of a Blue Book containing a report of the proceedings of a Royal Commission one or two questions and answers in illustration of the point he was referring to. 'Q. How long have you been an Associate Member of the Institution of Civil Engineers ? A. About two years. Would you like to know why it is such a short time ? Q. I did not ask you. A. Well, I would like to qualify the answer. The reason I did not become an Associate Member before was that when I contemplated coming to Australia I was certainly not aware that they thought so much of the fact that a man was a member of the Institution ; but when I arrived here I found, to my surprise, that they thought more of that Institution, in which the greatest number of duffers that I know in the profession are congregated, than of the University degree of Master of Engineering, which I hold, one of the highest in the United Kingdom. Learning that such was the case I became a member, as I say, two years ago. As a matter of fact, I could have been a member at least ten years previously. Q. But you are not a member now ? A. I am a corporate member now.' That gentleman was labouring under the delusion that the degree of 'Master of Engineering' in some strange way constituted a man an engineer. He proceeded in his evidence to talk about the admissible weight on the driving-wheels of locomotives for given weights of rails, and adduced calculations that were pitiful to contemplate. Sir Benjamin Baker never read anything more ridiculous in its way in his life. This 'Master of Engineering' found no difficulty in calculating the stress per square inch upon a rail under traffic to the hundredth of a ton, and in condemning a certain rail as too light. He had not enough practical knowledge, however, to see that the critical time in the life of a rail was not when it was new, but when it had lost, perhaps, 20 per cent. of its weight by wear and rust ; and he had only to apply his theory to a worn rail on the London and North-Western Railway, or any other important line in the world, to find that the stresses which he considered should not be exceeded were universally exceeded as a matter of daily practice with perfect safety ; and so his theoretical criticism went for nought. A case like this should serve as a warning to students against imagining that if they had taken a degree in engineering, or had left a University with the highest credentials, they were, therefore, necessarily engineers. No doubt they had been supplied with an invaluable box of tools, but if those tools were not properly used they might cut their own fingers very badly and also injure their employers. Theoretical knowledge was no substitute for the practical experience upon which their predecessors in this Institution had chiefly relied. This was not only necessary in works of the kind they were discussing, which really were very complicated as dealing with concrete and masonry, but also when apparently simple problems concerned with iron or steel were under consideration. For example, to take a very simple case, who was there among their students who would not be perfectly prepared to tell them what was the maximum stress per square inch on a tube of given diameter and thickness subjected to internal pressure of a certain amount within the elastic limit ? They would work out the answer to any number of places of decimals. Say that it was 7·55 tons per square inch. If the question was put to all the senior wranglers in the kingdom, they also would say unanimously 7·55 tons ; but if put to three poor mechanics, like the Director-General of Ordnance Factories (Dr. William Anderson), Sir Frederick Bramwell, and himself, they would say, 'We do not know.' It might be 7·55 tons, it might be 12·55 tons ; they could not tell nor even approximate to it unless they knew certain facts about the treatment of the steel which only practical men would consider of importance. That was a simple instance of the absolute necessity in practice of viewing with great suspicion theoretical deductions, which, from the great trouble involved in performing the calculations, often led one to attach too great value to the results."

AN ELECTRICAL PUMPING PLANT.

An electrical pumping plant has recently been designed and fixed by Messrs. Easton and Anderson at the brewery of Messrs. Warwicks and Richardsons, Newark-on-Trent. A source of water suitable for brewery purposes was found by sinking a well in a field about a mile and an-eighth from the brewery.

Messrs. Easton and Anderson undertook to supply plant for pumping this water by a motor to a tank on the top of the brewery. The question at once arose : Should the conductors be overhead or underground ? It was manifestly better that they should be underground, as it avoided the use of unsightly poles and wires, which would be more liable to injury, though, of course, more accessible for repairs ; the cost of underground cables suitable for the purpose appeared at first sight, however, to put them altogether out of court.

There was, however, one circumstance in which this work differed from the ordinary electric transmission plant, and that was that a water-pipe had to be laid to the brewery from the well, and this involved getting cut a trench. It occurred to Messrs. Easton and Anderson that if a pair of cables could be laid in the trench at the same time as the pipe the cost would be very materially reduced, and, on going into the matter, it was found that while the plan would not be cheaper than posts and naked overhead conductors, it was not very much dearer ; so that it was eventually decided to use the underground system. It was thought at one time that the pipe main might have been used for a return instead of a second cable, but the idea was not acted upon. It was considered desirable to be able to automatically vary the speed of the motor by varying that of the engine, and this condition was easily fulfilled by making the dynamo and motor both series-wound.

The plant is as follows :—The dynamo is of the "Whitehall" type, having slotted armature and double magnetic circuit, the field-magnets being of cast iron. It is, as before stated, series-wound for 360 volts and about 15 amperes at 900 revolutions. It stands on sliding rails, and is driven by a link belt from a countershaft which derives its motion by a belt from a horizontal single-cylinder non-condensing engine, which with the countershaft was already in existence. At present this engine does very little other work, but as it is too large for the pumping, it is contemplated to use it for other purposes, and therefore the pulley on the countershaft which drives the dynamo is fitted with a friction clutch, which enables the dynamo to be readily started or stopped as required, independently of the engine.

Suitable fuses and cut-outs are provided in the engine house, and from them the cable is led to the pumps. An ammeter is also fixed here, so that the engine driver can see that the current is being properly supplied. The cable was made by Messrs. Callender and Co., and is of their armoured type, so that it cannot easily be injured as it lies in the ground. The conductor consists of seven wires, each 0·054in. diameter, giving a total sectional area of 0·0155 square inches, and a maximum resistance of 2·84 ohms per mile, insulated by means of a solid sheet of vulcanised bitumen, taped and secured with jute yarn, armoured by means of 20 galvanised iron wires, and finished by a braiding of hemp yarn well compounded. It is laid in a special trench for a short distance till it joins the delivery pipe main leading to the tank, and from thence the two go together to the pump house, at a depth of about 2ft. below the surface of the ground.

There are only two joints on each of the two cables, and as the workmen laid the pipe they laid the cables, one on each side in the trench, leaving the part to be jointed open till the work was done, when a special man was sent by Messrs. Callender, who made the joints and tested the line. The pipe main consists of 5in. cast-iron socket and spigot pipe, for the most part jointed in the ordinary way. At one point the pipes have to cross a railway bridge over a canal, and here—in order to occupy as little space as possible—they are of wrought iron with flange joints, and are made only 4in. diameter, carefully enclosed and lagged to keep them from the effects of frost, the cables also being included in the same casing to preserve them from injury. The ground is low and wet, and the pipes and cable in some places pass under ditches, and were then actually laid below the water level.

The pump house is situated a few yards from the well. The outlet from the rising main at the tank is 70 to 80ft. above the

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surface of the water in the well. The pumps are of the ordinary three-throw type of Messrs. Easton and Anderson's standard pattern, with gun-metal valves. The barrels are 5½in. diameter and 12in. stroke. The pump crankshaft is driven from a countershaft by means of a cast iron pinion and wheel; and the motor in its turn drives the countershaft through the medium of a gun-metal pinion and a mortice wheel, the teeth of which are accurately machined to a special shape.

The motor is fixed on a concrete foundation, in such a way that it is readily accessible on all sides, which is a very desirable thing where space permits. It is of the same type as the dynamo, and is likewise series wound, to run with 260 volts at a speed of 600 revolutions, at which the pumps will make 28 revolutions per minute, and are calculated to deliver 5,000 gallons per hour to the brewery. The bearings of the motor are made self-oiling, by having each brass bush made in two lengths with a gap between them in which an endless pitch chain of brass rests on the spindle and dips into an oil well beneath the bearing. When the spindle rotates, it carries the chain round and brings up a supply of oil which is deposited on the spindle and finds its way along the bearings by means of grooves, eventually returning from the outer ends of the bearings to the oil receptacle. Thus the motor may run for weeks or even months without any attention to the lubrication being necessary. The lubricators on the pump are of the ordinary needle type, which last a considerable time without attention. For stopping and starting the motor at the pump house a suitable switch and resistance frame is provided.

A NEW FORM OF PORTABLE PHOTOMETER.*

BY SIR DAVID SALOMONS.

If two nicol prisms be mounted in a tube and a source of light is observed through them, then the amount of light which will reach the eye is governed by a well-known law depending on the relative positions of the prisms to one another. The quantity of light passing depends upon a function of the angle which the polarising plane of the polarising prism makes with the polarising plane of the analyser. And since one half of the light issuing from the source of illumination observed will never reach the eye (*i.e.*, the ordinary ray which is thrown out by the polariser), the light which reaches the eye will be half the original light multiplied by a function of the angle included between the polarising planes of the two nicols. This function is the square of the cosine of the angle included between the two planes mentioned. Consequently, the quantity of light reaching the eye from a given source will be governed by the well-known formula, as follows:—

Let I = intensity of the light observed,
,, L = light which reaches the eye,
,, O = ordinary ray in polariser,
,, E = extraordinary ray in polariser,
,, θ = angle between the planes of polarisation of polariser and analyser,

the light which reaches the analyser is E, or I/2, since O = E and I = O + E.

The amount of light which reaches the eye is expressed by the equation,

$$L = \cos^2\theta\, E \text{ or } L = \tfrac{1}{2}\cos^2\theta\, I;$$

hence L varies as $\cos^2\theta$.

In this instrument two tubes are mounted as a binocular capable of being adjusted for distance apart, in order to suit the eyes of different individuals, and the hinge portion used for such adjustment is made without a stop, so that the position of the tubes may be reversed in its relation to the eyes. Each of these tubes contains two nicols arranged as usual; but, instead of the analyser being revolved, the polariser is capable of being turned. The polarising plane of the analyser is set at 45deg. from the vertical in order to obtain the scales in a convenient position upon the tubes.

Consider for a moment one of the tubes—a description of which applies to the second. The polariser is so mounted that its position is indicated upon two scales at the same time, the one being graduated in degrees to be used for accurate work and the other graduated in divisions indicating what proportion of the light observed will reach the eye. One scale is called the "degree scale," and the other the "light proportion scale." The latter scale is so graduated that it reads unity for the "light field," and zero for the "dark field." The intermediate division numbers are 0·1, 0·2, and so on. This scale is used for approximate measurement.

When the "light proportion scale" reads unity the "degree scale" indicates 0deg., and when the former shows zero the latter scale reads 90deg.

* Paper read before the Institution of Electrical Engineers, March 23rd last.

The method of determining the positions of the divisions:—

We have $L = \tfrac{1}{2}\cos^2\theta\, I = \cos^2\theta\, \frac{I}{2}$.

Now equate ..... $\text{Cos}^2\theta = 0{\cdot}1$,

$\text{Cos}^2\theta = 0{\cdot}2$,

and so on.

Solve each equation, and the values of the angles so found are the successive points on the scale required. The following table gives the angles by working to three decimal places in making the calculation:—

Divisions upon the "light proportion scale."	θ.	
0	90°	no light passes.
0·1	71° 26′	
0·2	63° 34′	
0·3	56° 13′	
0·4	50° 14′	
0·5	45°	
0·6	39° 46′	
0·7	33° 47′	
0·8	26° 26′	
0·9	18° 34′	
1·0	0°	maximum light passes.

If the values for $\cos^2\theta$ for the right hand and left hand tubes are A and A′, and the values of the lights observed with the right and left tubes are I and I′.

Since the photometer is balanced at the start, each eye receives the same amount of light; it is therefore correct to equate $L = A\frac{I}{2}$ and $L = A'\frac{I'}{2}$. It is evident the result will remain unaltered if we regard these equations as L = A I and L = A′ I′, and it will save the observer the trouble of doubling the final result.

In front of the polariser a small round opal, or some equivalent, screen is placed; and the light upon this screen is that which is directly to be observed. The screen is mounted in a cell and on the end of the tube. A lens is inserted in the tube to focus this screen upon the retina. This screen may be removed. When desired, an adjustable lens may be added in front of the observation tube to focus the light in the plane of the screen. In some cases this may be convenient.

To make an observation with this instrument it is placed before the eyes in the same way as a field glass, each polariser having been turned to the position of "light field," when the "degree scale" will indicate zero degrees, and the "light proportion scale" will read 1. One tube is now directed towards the source of light under examination, and the other tube towards some known standard radiant. The distance of the light under observation, and the distance of the radiant from their respective screens (which are before the polarisers) are measured. Then, according to the usual methods of photometric measurement, assuming that the source of light under observation cannot be moved, it would be necessary to shift the standard radiant in order to get a balance—*i.e.*, to render the screen, observed by each eye, illuminated at the same intensity. Instead of shifting the standard radiant, the balance with this instrument is obtained by revolving the polariser which faces the brighter screen (should any difference exist) in order to reduce the illumination of both screens to the same apparent intensity. The value of the light under investigation in terms of the standard may be calculated when the amount of light cut off by the polariser, the distances of the two sources of illumination in question, and the value of the standard illuminant, are known.

It should be again observed that, since the ordinary ray reaches neither eye, it is equivalent to an equation each side of which is divided by 2; and, consequently, the final result will be the same as if no such division by 2 existed.

To make such an instrument thoroughly practical several mechanical appliances are necessary, and exist in this instrument. It will be a convenience if the standard radiant can be placed always at such a distance that the square of this distance shall be unity; and instead of this radiant being in front of the instrument—which would cause it to shed light on the other screen, or be in the way—it should be placed at the side, and illuminate its screen by means of a right-angled reflecting prism, and the arrangement is such in this apparatus.

The comparison radiant for this instrument consists of a standard candle contained in a tube, the candle being fed up by means of a spring, the top of the tube forming an abutment to keep the candle flame at one level, although the length of the candle is always altering. This abutment piece is surrounded by a cup to catch any grease which may run over. The candle tube has a slot cut in it in order that the amount of candle in the tube may be observed at any moment. The candle tube is carried in a light framework, which supports a metal cylinder that acts as a chimney to keep off draughts. This chimney has in it a small window into which slides a slip of clear glass, and it is through this window that the light

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from the candle passes to illuminate its screen. The clear glass may be replaced by tinted glass when desired.

The chimney is carried in a special form of gimbals, so that, no matter what inclination may be given to the binocular, the candle will always remain vertical, since the gimbals are attached to the binocular by means of an arm. The inner ring of the gimbals is in reality only half a ring, and the plane of the outer ring when the candle is vertical, instead of being at right angles to the axis of the candle, is oblique to its axis. This construction is necessary, otherwise the rings would come before the window in the chimney and so obstruct the light. In front of this window is placed a suitably-shaped tube capable of being lengthened and shortened, if required, and which fills up the space between this window and the reflecting prism, this prism being situated in front of the screen at the end of the tube containing the nicols. The object to be secured is that extraneous light should be kept from this screen. The weight of this adjusting tube is counterpoised so that the candle may always remain vertical. The arm connecting the candle with all its supplementary apparatus is carried upon its observation tube (which contains the nicols) by means of a ring arranged in such a way that, although removable, it cannot turn except to a small degree by means of an automatic motion. The reflecting prism also is carried in a similar way. The arm has two motions upon it—one a clamping joint to enable the candle flame to be brought in front of the prism to a nicety and the other a kind of parallel motion arrangement by which the candle can be placed to two given distances from the prism, according as the parallel arrangement (somewhat similar to a parallel ruler) is pushed to the one side or to the other. The measurements and the arrangements of the details are all so adjusted that the candle flame will always be facing the reflecting prism for all inclinations of the binocular, and the two distances to which the candle may be moved are so regulated that the apparent distances of the flame from the screen it illuminates shall be either the square-root of 10 or the square-root of 12. These two distances are the most convenient, one for use when measuring by a decimal system, and the other when measurements are made in feet.

It may be mentioned that the candle arrangement with its arm can be removed at pleasure, so also can the reflecting prism. It will be noticed that the weight of the candle with its apparatus tends to twist the ring round upon the tube containing the nicols, and it might appear that this could be avoided by simply cutting a slot in the ring to push over a pin screwed into the nicol-tube. This, however, is not feasible; for, in order always to have the relative positions of all parts as they should be, it is essential that the ring which carries the candle and its arm should have a slight circular motion. This is obtained by placing upon the direct observation nicol-tube another ring, which is connected with the candle-arm ring by means of a slotted sliding bar in such a way that the candle apparatus cannot be displaced and the relative positions are always correctly maintained.

A description of this part, simple as it is, would be complex, so that references must be made to the plates attached hereto, by the inspection of which the arrangement will appear clear. The eyes of any one person differ, so that an observation error is sure to be introduced. In order to eliminate this error, the instrument is so arranged that the relative positions of the parts of the instrument can be reversed when a second observation is taken, which is equivalent to an observation with the eyes reversed. A mean of the two observations is then taken. The instrument described has this particular advantage not possessed by other photometers.

At starting it is only necessary to place the candle in its fittings on any of the photometers in general use, in order to ascertain the standard value of the light which issues from the window and from the tube when the latter is used. These two values, which may practically be considered as constants, can be engraved upon the chimney. The loss of light due to the reflecting prism may be ascertained at the same time.

When it is desired to put the instrument (set up and the candle alight) upon a table, it is placed upon a small slender tripod. This tripod, which can be closed to render it portable, accompanies the instrument. It may often be found convenient, when using this apparatus, to place it upon a tripod after the same manner as a theodolite.

This photometer packs up into a sling case barely larger than those used for field glasses.

Some of the advantages derived from this instrument may be stated as follows:—Very powerful arc lights may easily be compared with one another or with a standard source of light. It may be used for measuring various sources of light, such as daylight out of doors with light in a room, and for the estimating of photographic exposures. That the instrument is exceedingly convenient, compact, portable, and easy to use, need scarcely be stated. It may also be employed for rapidly comparing the light in one or more places far apart, which is frequently a great convenience.

Two points alone might be urged against the principle. The first is that nicol prisms are not, as a rule, sufficiently accurate for very close measurements. However, to make these prisms quite accurate, or at any rate sufficiently so for this purpose, is no difficult matter, as may easily be proved by taking a number of nicol prisms at random and testing them. Secondly, errors are introduced due to internal reflections as well as reflections which take place at the surfaces of the prisms. These losses occur for the nicols in both tubes, and when the losses in each tube are deducted from one another for any positions of the nicols, the difference will be found to be so small as to affect to an inappreciable extent the result.

The nicol prisms in the tubes might be dispensed with and be replaced by adjustable diaphragms somewhat similar to the "Iris" pattern, one being placed in each tube, and an index scale showing the area which is free for the light to pass, as well as a proportion scale for reading the quantity of light which passes without calculation. The principle, of course, would remain the same as that already described.

Again, it might be possible to vary the proportion of light passing down the tubes by wedges of tinted glass; but, on the whole, the nicols appear to present so many advantages that a preference was given to their use.

Appended hereto are the formulæ applicable to this apparatus for general work, and it will be unnecessary to refer to any tables or to make tedious calculations excepting in those cases where great accuracy is required, in which event the scale of degrees must be used and the values of the cosines be looked out and squared.

Let X = the light under examination,
" l = the comparison light expressed in standard candles,
" D = the distance in inches of X from the screen of the photometer facing X,
" d = the distance in inches of l from the screen of the photometer facing l,
" θ = the angle between the polarising planes of the nicols in the tube facing X,
" θ' = the angle between the polarising planes of the nicols in the tube facing l;

Then $$\text{Cos}^2\,\theta\,\frac{X}{D^2}=\cos^2\theta'\,\frac{l}{d^2},$$

and $$X=\frac{\cos^2\theta'\,D^2}{\cos^2\theta\,d^2}\,l.$$

Let $$\text{Cos}^2\,\theta=A \text{ and } \cos^2\theta'=A',$$

then $$X=\frac{A'}{A}\,\frac{D^2}{d^2}\,l.$$

In this photometer d may be made $\sqrt{10}$ or $\sqrt{12}$, so that the last equation may be written,

$$X=\frac{A'}{A}\cdot\frac{D^2}{10}\,l \text{ or } \frac{A'}{A}\cdot\frac{D^2}{12}\,l,$$

according to the value of d.

If D is divided by 12 the distance will be expressed in feet.

Let $$\frac{D}{12}=D'$$

then $$X=\frac{A'}{A}\cdot\frac{D^2}{12}\,l \quad \ldots\ldots\ldots (1)$$

when distances are given in inches,

and $$X=\frac{A'\,D'^2\,l}{A} \quad \ldots\ldots\ldots (2)$$

when distances are expressed in feet.

When the values of A and A' are calculated from the "degree scale," certain special cases occur which simplify the equations. They are when $\theta=0$ deg., $\theta'=0$ deg., $\theta=\theta'=0$ deg., $\theta=45$ deg., and when $\theta'=45$ deg. In these cases A and A' will become unity for 0 deg. and $\frac{1}{2}$ for 45 deg.

With most observations the value of A' will be 1, and equations (1) and (2) will then become

$$X=\frac{D^2\,l}{10\,A'}, \quad \ldots\ldots\ldots (3)$$

and $$X=\frac{D'^2\,l}{A}. \quad \ldots\ldots\ldots (4)$$

When the values of A and A' are obtained from the "light proportion scale," the values are in decimals of one place, so that these figures may be read as whole numbers multiplied by 0·1.

Equations (3) and (4) may then be written

$$X=\frac{D^2\,l}{10\,A\times 0{\cdot}1}=\frac{D^2\,l}{A}, \quad \ldots\ldots (5)$$

and $$X=\frac{D'^2\,l}{A\times 0{\cdot}1}=\frac{10\,D'^2\,l}{A}. \quad \ldots\ldots (6)$$

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Putting these equations into words :—

Rule 1.—When only the light under observation is reduced by turning the polariser, the "light proportion scale" is used, and the distance of this light from the screen is given in inches, then the square of this distance multiplied by the standard comparison

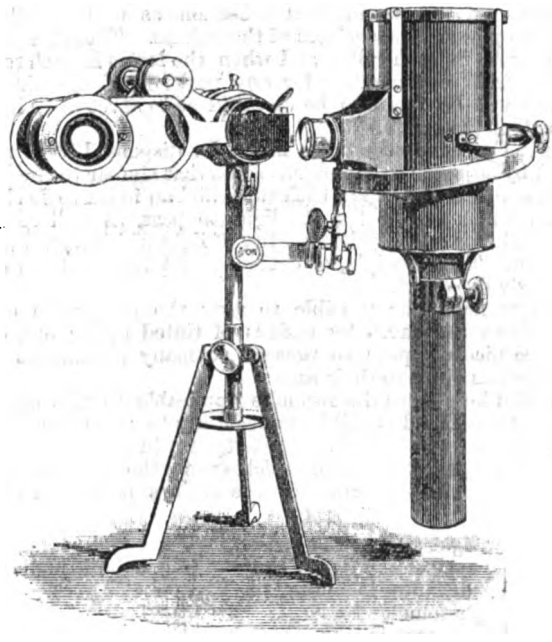

FIG. 1.

light in candles and this product divided by the reading on the "light proportion scale" (read as a whole number) gives the value in standard candles of the light observed.

Rule 2.—When only the light under observation is reduced by turning the polariser, the "light proportion scale" is used, and the distance of this light from the screen is given in feet, then the square of this distance multiplied by 10 and by the standard comparison light in candles and the products divided by the reading on the "light proportion scale" (read as a whole number) gives the value in standard candles of the light observed.

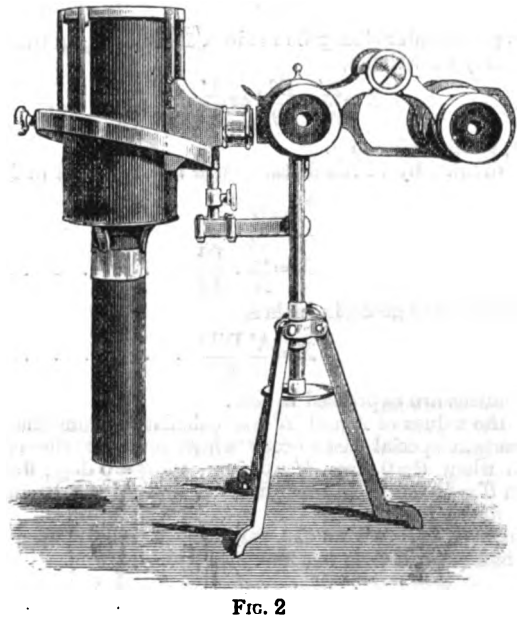

FIG. 2

Fig. 1 shows the instrument set up for use upon the tripod. On the right is shown the candle-tube, with chimney and screening tube, set in its gimbals, the whole supported by the arm which connects it with one tube of the binocular. The tube of the binocular nearest the candle has the reflecting prism upon it. The end of the other tube shows the opal screen. The long link embracing this tube and connected with the other one is the portion which gives the automatic adjustment to the reflecting prism and candle arm. The distancing arrangement for the candle is seen at right-hand end of the candle-arm.

When the photometer is used it is lifted off the tripod.

Fig. 2 is the reverse view of the last one, and shows the appearance of the instrument as seen from the side which faces the eyes.

Fig. 3 shows the arrangement of the binocular portion of the photometer diagramatically. At the top is shown the scale of divisions of the "light proportion scale." In the centre the end view of binocular is illustrated, showing on one tube a screen, and on the other tube the reflecting prism covering its screen.

The lower diagram is a side view. On the left tube is seen one scale, the second one is on the other side. The centre portion

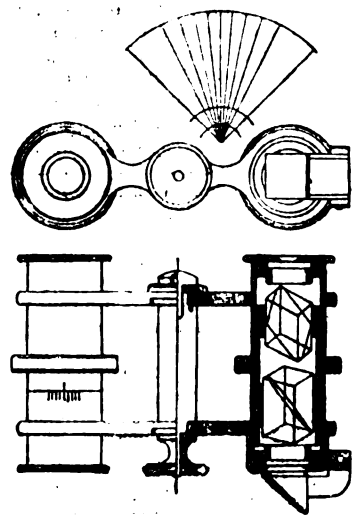

FIG. 3

is the hinge with a clamping nut, and the right tube is shown in section, with the reflecting prism attached.

DISCUSSION.

Mr. ROBINSON asked whether the standard of light could be taken at once ; for instance, in comparison with the unit of light could any test be made directly of the light?

Sir DAVID SALOMONS : Yes.

*Prof. CROOKES said they were greatly indebted to Sir David for bringing before them so very compact, portable, and beautiful a form of photometer ; but there was one weak link in the chain, and a chain was only as strong as its weakest link. Sir David used a candle as a standard. Now, a candle was the most imperfect standard that one could have. No two standard candles agreed. He thought he was under the mark in saying that there were variations of 10 per cent. between one set of standard candles and another. He knew that candles were very largely used for photometric purposes, but they were admitted to be so imperfect that he thought electrical engineers ought to devise something better and more trustworthy, and he did not think that the difficulties were at all too great to be got over if attention was devoted to the subject.

*Mr. TROTTER said that he felt hardly competent to offer any remarks upon the Paper, as he had not had the pleasure of reading it, and could not quite comprehend the instrument from the short description of it which they had just heard ; still less could he criticise such an instrument until he had worked with it. There was always a difficulty in eye-piece instruments. He remembered Captain Abney calling attention some time ago to the great advantage in photometric work of looking at the screen from a distance, and with both eyes. One felt a great constraint with eye-piece instruments, and he was quite sure that was one reason why the German so-called subjective method of reading galvanometers was not used much in this country. It seemed that the half-image principle which was so familiar in saccharimeters could be applied to this. Looking through one eye-piece only, they would have the light reflected from the prism through half the telescope, and through the other half they would see the light to be compared with it. A candle was very bad as a standard, but in a photometer they wanted a secondary standard only to carry about to compare with the standard which was kept at home ; in the same way, a foot rule was not the standard, it was only a secondary standard, which was carried about, which one believed had been checked by somebody at one time or another against a real standard. In that way a glow-lamp would be a good secondary standard, because it could be checked before leaving home upon a photometric expedition, and again on coming back. In ordinary photometric work, where a standard candle had to be used, a good many calculations and corrections had to be made in order to get anything like accuracy.

*Prof. AYRTON confessed that he felt some doubt, not having used the instrument, as to the ease with which they could compare two lights when they were looking at one with one eye and at the other with the other eye. The two eyes would give one appearance, and it would be very difficult to know which of the two lights was the brighter. He had found a candle pushed up by a spring through the nozzle to be very uncertain as to its illuminating power. There was another thing which it was very important to be able to do with a photometer when they were comparing lights of very different colours, that was to be able to vary the inten-

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sity of one of the lights rapidly backwards and forwards, rapidly diminishing the amplitude of the oscillation to a point which they stopped at. He quite agreed, therefore, with Mr. Crookes that the glow-lamp formed a much better standard. There was no necessity, however, to use an ammeter and voltmeter; it was quite sufficient to use an ammeter. If they knew the current through the lamp, then they would be able to get the brightness of the light. He might take this opportunity of mentioning that he had had experiments going on in his optical laboratory for some years past, with running lamps at very much below their normal brilliancy. He did not propose to state now how far they had obtained perfect constancy, but the experiment that they had been trying (and it had been going on now for some years) was to see whether they could or could not say that the light given out by a lamp, when a perfectly definite current was sent through that lamp (which was never raised to anything like like its normal brilliancy, so that, practically, there was no fear of blackening the glass), would for years be a perfectly definite thing. He was in hopes that the result would be "yes," but he was not quite clear about it yet, although it was sometime since they started the investigation. Supposing the answer was yes, then all they had to do was to take a glow-lamp and send through the filament of that glow-lamp a certain definite current which it would be very easy to measure with perfect accuracy by means of a set-up ammeter, that is an ammeter which read between two limits, whatever they might be—the tenth of an ammeter and the fifteenth of an ammeter—a *current gauge* which read one current with extreme accuracy and read no other current at all. He hoped to be able to supply a practical standard of light which would have none of the disadvantages of the standard candle, which would not, of course, be affected by wind, and which would give exactly the same results from one time of the year to another.

*Mr. FAIRFAX said that he had been making some photometric experiments for the last two years upon daylight. Although the north light was supposed to be extremely steady, yet if there were clouds passing across, the light would vary within ten or fifteen seconds. He had been doing that with a very simple arrangement. It was just a silver napkin ring. Mr. Lovibond, who invented the tintometer, told him that the only white light that he could get was that of a sea fog.

Sir DAVID SALOMONS: Will you show us how you use it?

*Mr. FAIRFAX: I simply put it on a white surface. The various rays of light fall as a cardioid curve on a white horizontal surface placed beneath it. The main point to be observed is that either the photometer or the source of light should always be at a certain definite angle, so that in measuring two lights, one at a greater distance than the other, the angle with the ring should always be the same.

*Sir DAVID SALOMONS, in reply, said that the discussion had turned chiefly upon the candle, which was the part that he attached practically no importance to, for the reason that he knew it was extremely imperfect. In order to try and limit the error as far as possible, he had arranged to cut down the light something after the Methven standard method, to make up a little for the deficiencies which would otherwise exist, and to case it with metal fairly close, so that a draught might be started very soon after it was lit. It was tested with a photometer before using; it should be taken at a time when the temperature did not appear to rise beyond the average temperature. The error was not very great, and a candle was one of the most convenient things which could be used at the present moment for carrying about. Incandescent lamps were undoubtedly far better, but they were not convenient things to carry in the pocket together with a secondary battery. Curiously, when Lord Kelvin looked through the instrument the axis of his eye appeared to be somewhat different to that of most people. Lord Kelvin could only see one image like a stereoscopic image. Most people who had looked through it saw two images. The reason why in a binocular, an ordinary field glass, only one image was seen, was the fact that what they were looking at was very far off. In the stereoscope it was necessary to get over the difficulty caused by the fact that the objects were near, and therefore they must have the lenses prismatic in form. They would see two images, not one, unless the axes of the eye were placed a little different to what was usual. No doubt in certain classes of close work, as in watchmakers' work, the axes of the eyes did get somewhat altered from the normal. A Jellett prism would do really what Mr. Trotter suggested, but it was almost impossible to get a perfect Jellett prism cut. It was more a prism of theory than a prism of practice.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April* 21, 1893.

Electricity at the Chicago Exhibition.—The installation of the exhibits in the electrical building has not proceeded very far up to the present time, but those in charge are confident that the great majority of them will be in proper shape at the opening on May 1st. The floor of the building is covered with packing cases containing exhibits, and these are being taken out as rapidly as possible. The foreign exhibits make a particularly good showing. The immense tower of the General Electric Company is now in process of erection, and when completed will undoubtedly be the most conspicuous object in the building. The Bell Telephone Company is also erecting a building which will attract much attention, and will probably contain a very elaborate exhibit of telephone apparatus. Only one or two of the exhibits are as yet complete. A small army of men are busy, and a few days will undoubtedly see the work nearing completion.

Rapid Transit in New York.—At last the Rapid Transit Commission, after two or three years and the expenditure of some $250,000, has settled upon some definite plan of rapid transit in New York. It may, however, be considered as a temporary relief and as not intended to end the matter or to preclude the possibility of the construction of other lines in the near future. An underground electric railroad was considered by the Commissioners as the ideal method of transportation under the existing conditions, but it will be remembered that when the franchise for the construction of such a road was offered for sale, some months ago, only one bid was received, and that was so ridiculously low that it was not considered. Finding their efforts in this direction blocked, the Commissioners turned their attention to the extension of the present elevated system. An underground road, however, was not lost sight of, and some days ago two propositions were made to the Commission by the banking house of R. D. Wilson and Co., who proposed to organise a company with a capital of $15,000,000, to construct and operate an underground road on condition that the city should loan its credit to the Company to an amount equal to 70 per cent. of the actual cost, the amount, however, not to exceed $35,000,000. Upon investigation it was found that the city could not enter into such an agreement constitutionally, and a second proposition was made to the effect that a company with a capital of $15,000,000 should be formed, and that the city build the road and sell it to this Company at cost; or for the Company to build a small portion of the road and the city to build the rest, which was to be sold to the Company upon its completion. The Mayor of New York, whose veto power in this case is absolute, expressed himself as decidedly opposed to any such arrangement, and the proposition was rejected by the Commission. A few days later the Rapid Transit Commissioners unanimously adopted a plan for the extension of the present Manhattan Elevated Railroad system.

The Columbia Incandescent Lamp Suit.—The case of the Edison Electric Light Company, *et al.* v. Columbia Incandescent Lamp Company, which was tried on April 11th, 12th, 13th, and 14th, excited widespread interest in electrical circles. A very strong case was made, and what has become known as the "Goebel defence" was set up and supplemented by new affidavits, which reached several hundred in number. To-day a decision was handed down by Judge Hallett in favour of the defendant. This decision was in the case of a motion for a preliminary injunction, and two courses are now open to the General Electric Company, first, to press the suit to a final hearing, which would involve the examination of all the witnesses whose affidavits were produced, which would consume probably two years' time, during which the Edison patent probably expire; second, to let the matter drop entirely and allow the few remaining companies which have not been enjoined to continue the manufacture of incandescent lamps. In either case the effect on the lamp industry will be very beneficial.

BOOKS RECEIVED.

"Official Catalogue of the British Section" of the Chicago Exhibition. (London: William Clowes and Sons.) 540 pp., 8vo. Price 25 cents.

"Proceedings of the Royal Society." Vol. LII., No. 320. (London: Harrison and Sons.)

"The Romance of Electricity." By John Munro. (London: Religious Tract Society.) 320 pp., crown 8vo. Price 5s.

"Official Guide to the World's Columbian Exposition, 1893." (London: Reuter's Telegram Company.) European Edition. Price 1s.

"Alternating Currents of Electricity," authorised American edition, by Gisbert Kapp, with an introduction by William Stanley, jun. (New York: W. J. Johnston Company.)

City and Guilds of London Institute: Report to the Governors, 1893. (London: Gresham College.)

"Electricity and Magnetism," by S. R. Bottone. (London: Whittaker and Co.) Crown 8vo.; 200 pp.

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CORRESPONDENCE.

GAS POWER FOR ALTERNATING-CURRENT WORKING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In criticising my letter on the above subject in your last week's issue, you seem to have slightly misunderstood me. What I want to point out particularly to gas-engine makers is the importance of "parallel" running in alternating-current systems. You seem to imagine that gas-engine manufacturers are well aware of this, and that my letter was uncalled for. To show you that this is not so, I may mention that, in correspondence which I have had with a leading firm, they admit that they have not taken the trouble to consider the question because they believed *that the use of alternating currents would die out.*

I did not suggest in my letter any alteration of the Otto cycle, but some convenient and cheap arrangement of cylinders to keep up coutinuous impluses. I believe there should be no difficulty in successfully varying the impulses down to half-power.

That the dynamos in a central station should not be arranged to work at light loads does not alter the fact that the chief firms do not make engines capable of driving alternators in parallel *at all*, even at heavy loads.—Yours, &c.,

J. A. MCMULLEN, M.I.E.E.

21, Carlton-hill, St. John's Wood,
London, N.W., May 5, 1893.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1893 Edition of "THE ELECTRICIAN" Electrical Trades Directory and Handbook is NOW READY. This useful book contains over 1,000 pages, and several new and handy features have been added. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

TENDERS INVITED.—The Ealing Local Board invite tenders for the construction of Lancashire boilers and accessories, which must be in by 12 noon on Wednesday next, the 17th inst.

——— The Urban Sanitary Authority for the Ealing district require tenders for the construction of the necessary machinery and accessories for their electric-lighting scheme. Messrs. Bramwell and Harris, of 5, Great George-street, Westminster, S.W., or Mr. C. Jones, C.E., Surveyor to the Local Board, Ealing, will show the plans any time after Monday the 15th instant, and all specifications and forms of tender can be obtained from either. Tenders must be in by Tuesday, the 30th instant.

——— The tenders invited by the Rochdale Corporation for lighting their Sanitary Works were due yesterday.

——— The Direction-Générale des Postes et des Télégraphes invites tenders for the supply of apparatus for telegraph offices during 1893, in 18 lots. Forms of tender must be obtained before the 14th inst., at the Fourth Bureau of the Division du Matériel et de l'Exploitation Électrique, 153, Rue de Grenelles, Paris, where tenders will be opened on the 24th inst.

TENDERS ACCEPTED.—The Corporation of Dewsbury at their meeting last week provisionally accepted a number of tenders in connection with their electric-lighting scheme, the total amount being £12,000. These tenders will be officially accepted at the next meeting of the Town Council.

——— The Corporation of Cardiff have accepted the tender of Messrs. W. Thomas and Co. for the erection of the first portion of the electric-lighting station at Canton, the amount being £3,328 3s. 2d. This tender was the lowest of four sent in.

——— In *The Electrician* last week, by a misprint Messrs. Simmons and Co. were given as the successful tenderers for the supply of a switchboard to the Aberdeen Corporation. The name should have been Messrs. Siemens, Bros. and Co. (Limited).

APPOINTMENT VACANT.—The Hanley Corporation require an electrical engineer to superintend the construction of the works for the supply of electricity now being carried out for the borough, and to take the management of the works when completed. The salary is to be £200 per annum. Applications must be sent into Mr. Arthur Challinor, Town Clerk, by May 30th.

BANKRUPTCY.—In the case of John Herbert Hale, lately carrying on business at 25, St. Stephen-street, Bristol, as an india-rubber merchant and electrician, the liabilities amount to £722 3s. 5d., and the assets to £405. 5s. 4d.——Austin Herbert, formerly in business as an electrician at Nottingham, but recently adjudicated a bankrupt with liabilities to the amount of £172, and assets £55, has passed his public examination.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The Glasgow offices of this Company are now removed to more commodious premises, at 4, Waterloo-street.

THE EDISON AND SWAN COMPANY.—Owing to the large demand upon the City offices of this Company, in Cannon-street, E.C., it has been found necessary to further extend this branch, and additional premises have been taken at 7, Suffolk-lane, E.C., where the office and general business of the City branch will be carried on.

ALLPRESS AND CO.—Mr. Vincent S. Allpress informs us that he has retained the offices of the late firm of Allpress and Belshaw, Victoria-street, Westminster, S.W., where he will carry on business as an electrical engineer and contractor, under the above name.

THE IMPERIAL INSTITUTE.—The electrical apparatus enabling communication with the belfry to start the large peal of bells on the occasion of the opening ceremony was designed and erected by Messrs. Julius Sax and Co. (Limited). The electric lighting of the Queen's lift and the telephonic and bell installation throughout the building was also supplied and erected by this firm. The hydraulic lifts, of which there are several, have been erected by Messrs. Archibald Smith and Stevens.

BOY MESSENGERS.—The business of the Boy Messenger and Electric Call Company (Limited) has been taken over by the District Messenger Service and News Company (Limited).

CEILING ROSES.—We give below an illustration of a new ceiling rose designed by Messrs. King, Mendham and Co. It is made in china and consists of two parts, the plug and its cover, the latter serving as cover and base combined. The plug is divided into four parts by webs and the terminals are fixed through these webs, as shown; an additional terminal is provided to carry the fuse. In wiring, the flexible cord is threaded through holes and knotted before being attached to the proper terminals, and the branch wires are brought through holes in the base of the plug. The wirer is thus able to do his work away from the ceiling, except when he is securing the cover to the block by the three screws. No twisted cord is required, the knot being tied in each single stranded cord, and this relieves the terminals of the weight of the lamp and shade. No thread is used, and as the plug fits loosely into the cover these parts are interchangeable. The makers claim that this rose can be used with high voltages and in any position.

The K.M.B. "Perfect" Ceiling Rose.

THE OERLIKON ALTERNATE-CURRENT MOTOR.—We have received from the above Company their latest list of alternate-current motors, which gives full description, photographic illustrations and details of the machines. These are self-starting and may be switched in, like a direct-current motor, without any series resistance if the machine be started by hand; while the large current at starting does not injure the motor as it would a direct-current one, since there is no commutator or collector. The standard types are from ⅛ to 9 H.P., and vary in speed from 1,800 to 1,150 revolutions per minute, the speed for any individual machine not varying more than 5 per cent. from no load to full load. The efficiency rises from 40 per cent. in the ⅛-H.P. machine to 80 per cent. in the 9-H.P. machines, and the weight from 92lb. to about 10 cwt., and the motors are designed for a frequency of 65 ∿, and a pressure of 110-120 volts. Unfortunately, the most important detail is omitted—the *price* column is left blank. The practice of leaving the prices out of a list is one which is also common in England, and is to be deprecated; it is apt to give customers the idea that the price varies as the customer.

LIVERPOOL OVERHEAD RAILWAY.—We have received from the Electric Construction Corporation an illustrated description of the Liverpool overhead railway and its plant.

ALUMINIUM SOLDERS AND ALLOYS.—Mr. W. A. Briggs, of Dundee, sends us a circular relating to Prof. Richard's solder, and to two alloys, one claiming double the strength of aluminium. The

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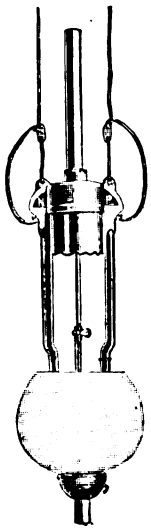
prices being left blank, we are unable to judge of the practical importance of this material. Another alloy is offered for ornamental purposes, in ingots at from 1s. 1d. per lb.

THE WATERHOUSE ARC LAMP.—This is a simple and strongly-made lamp, intended either for series or for parallel running. The feed is a modification of the Brush clamp, but instead of a glycerine dash-pot, a piston is provided on the top of the carbon rod, and works in a brass tube which is screwed to the case. An asbestos cupped washer is fixed on the piston, which while allowing the rod to be moved freely upwards, allows it to descend slowly. Differential magnets and an air dash-pot are used for striking and feeding. The working parts are mounted on a single casting, and a cast-iron



hood, having no screwholes other than for the brass tube already mentioned, protects the lamp from the weather. The upper carbon holder is arranged with a ball and socket as in the Hochhausen lamp. We are informed that only single-carbon lamps are being made at present.

"THE ENGINEERING MAGAZINE."—The May number of this popular American monthly is now ready, price 1s. Vol. V. commenced with the number for April, and the annual subscription to the magazine is 12s. 6d., post free. The contents for May include "Ethics of Architectural Competitions;" "The Gravity System of Rapid Transit;" "Progress in Steam-Engineering," by Prof. R. H. Thurston, Past President Am.Soc.M.E.; "The Cost of Street-Railway Building;" "Prof. Gray's New Telautograph;" by William Maver, Jun.; "The Care of Existing Highways;" and the second part of "English and American Railways," by W. M. Acworth, together with notes on Mechanics, Architecture, Mining and Metallurgy, &c.

"ELECTRICITY THE LIGHT OF TO-DAY."—Under this title Messrs. Sharp and Kent have issued a most attractive book of excellent collotype illustrations of electric-light fittings, with their prices. Interspersed among these are a number of very well executed coloured plates. Though nothing but a catalogue of fittings, Messrs. Sharp and Kent have succeeded in striking out an entirely new line, even where the highest class of printing and pleasing binding has of late been ungrudgingly used. This production may be looked upon as a praiseworthy endeavour to popularise electric lighting, quite as much as an effort to put forward a striking catalogue.

MESSRS. ERNEST SCOTT AND MOUNTAIN (LIMITED).—This firm have secured the contract for lighting the Burnopfield Co-operative Society's extensive premises. The plant will include a 7-H.P. "Priestman" oil engine.

ABERDEEN.—A committee of the Directors of the Northern Co-operative Company have consulted Prof. Kennedy on the subject of lighting their large premises in Loch-street and Gallowgate by electricity. Prof. Kennedy will furnish a report showing the cost of fitting up and working the installation comparatively with that of gas.

BLACKBURN.—Mr. Thomas has been duly elected by the Town Council to serve as electrical engineer during the installation of the electric light in the centre of the town. The appointment is not, we understand, a permanent one.

BOLTON.—Plans for the buildings required for the proposed Central Station have been submitted by Mr. Ryder, the electrical engineer to the Corporation, and have met with the approval of the Gas Committee. Messrs. Hinnell and Murphy have been appointed architects, and the scheme is now to be actively proceeded with.

BRISTOL.—The Electrical Committee of the Corporation will recommend the acceptance of the tender of the Brush Electrical Engineering Company for the supply and erection of transformers, terminal boards, &c., at the various sub-stations, for the sum of £1,752, and the tender of Mr. F. M. Newton for the supply and erection of switchboards, storage batteries, &c., at the central station, for the sum of £1,553. 10s.

BUCKINGHAM.—The charge made by the local Gas Company for lighting the Town Hall clock has averaged between £10 and £11 per annum. Messrs. Parr and Gillies, proprietors of the local Electric Light Company, offered to do the lighting for £5. 6s. per annum; this has brought an offer from the Gas Company to light the clock for £4. 10s.

BURY.—The report of the deputation recently appointed to visit London and several other large towns with a view of studying the electric-lighting question, has been duly presented to the Town Council, and recommends that the Borough Engineer be instructed to prepare conditions upon which a limited number of contractors shall be asked to submit competitive tenders to adopt or recommend such systems of supply and types of motive-power as they must deem best suited to meet the conditions under which the electric lighting for the borough is to be installed. The deputation further recommend that a consulting electrical engineer be appointed to act with the Borough Engineer to advise the Electric Lighting Committee in the preparation of the drawings, estimates, and specifications for the necessary work. The whole of the subject was discussed at the last meeting of the Town Council, and, with slight amendment, the recommendations of the report were adopted.

CITY OF LONDON.—A Court of Common Council has given permission for the City of London Company to carry their mains and tubes over London Bridge. An objection having been taken that the Company had been laying telephone tubes in conjunction with their lighting tubes, Mr. Hudson, on behalf of the Bridge House Estates Committee, assured the Court that the application only related to electric-lighting tubes.

DERRY.—Active preparations in connection with the public electric light installation are reported. The contractors are at work on the generating station at Strand Road, and the number of the standards for the street lamps have already arrived. It is expected the works will be completed before the autumn.

DORCHESTER.—Authority has been given by the Town Council to their General Purposes Committee to consult Mr. F. M. Newton, of Taunton, as to the cost of providing the town with the electric light.

EDINBURGH.—A largely-attended public meeting of the ratepayers of the Calton Ward was held last week to consider the question of lighting the city by electricity. It was pointed out by one of the members of the Town Council that the time had come when urgency should be given to the matter, as the Provisional Order was imperilled by the delay which had already occurred. Ultimately, the meeting broke up without arriving at any satisfactory conclusion on the subject, a motion and an amendment only receiving about 50 votes. The object of the organisers of the meeting was to obtain the opinion of the ratepayers upon the decision of the Corporation to take the electric lighting into their own hands, and not to transfer its working to a local company.

ELECTRICITY IN MINING.—The New Zealand Government have authorised an important inquiry to be made as to the application of electricity as a motive power to gold-saving batteries, the current to be generated by means of a waterfall within a few miles of the "Quaotunu Field," where considerable difficulty has been experienced in saving the gold from the ores, owing to the cost of working the batteries. The ore is low grade. The Government have decided to send Mr. Fletcher, electrical engineer, and Mr. Gordon, their Inspector of Mines, to report as to what can be done in the matter.

ELECTRICAL TRADES' UNION.—We are informed that the annual conference of this Union will be held at the Black Boy Inn, Groat Market, Newcastle, during Whitsun week. The Union claims to have a membership of over 3,200, and in all 32 branches. On the 20th inst. there is to be a mass meeting of electrical workers at Newcastle which is to be addressed by Mr. Gooday, the general treasurer, on the subject of "A Legal Eight Hours Day and its Relation to the Unemployed."

GLASGOW.—The electric light at Free St. Paul's Church is now an accomplished fact. The work has been carried out by Messrs. MacLellan and Co. to the satisfaction of the pastor and congregation.

HARROGATE.—The borough surveyor and Mr. Wilkinson, consulting engineer, are preparing a scheme to lay before the Corporation with regard to the Electric Lighting Order. The matter is to be referred to the General Purposes Committee.

HENLEY.—Ferry Lodge, Wargrave, is to be lighted by the electric light, the contract having been placed with Messrs. Laing, Wharton and Down.

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HOVE.—The Town Hall Committee of the Hove Commissioners, having further considered the offer sent in for wiring and providing fittings for lighting the Town Hall by electricity, have recommended the Commissioners to provide their own wires and fittings, and to apply to the Local Government Board for sanction to borrow £1,400 to meet the estimated cost of the work.

HOWRAH, INDIA.—Messrs. Martin and Co., in conjunction with Messrs. Burn and Co., are, we learn, preparing a scheme for lighting the streets of Howrah by electricity at an estimated cost of two and a-half lacs of rupees (nearly £17,000). Both public and private lighting are embraced in the scheme, which will shortly be submitted to the Municipal Commissioners of Howrah for approval.

ILFORD.—At a meeting of the Ratepayers' Association it was agreed that no sufficient reason had been shown by the Local Board why the proposal to adopt the electric light for the town had not been accepted, except in the fact that the interests of the local Gas Company were strongly represented on the Board.

KIDDERMINSTER.—Mr. A. Bromley Holmes, who was selected to advise the Law Committee on the subject of electric lighting, has advised the adoption of a low-tension direct-current system. He estimates the cost at about £15,000 for a station and plant capable of supplying 3,000 16-c.p. lamps, provision being made for an extension of the lighting subsequently. The Committee recommended that the usual circular be sent to probable users to enable them to estimate the demand for the light, for which it is proposed to charge 6d. per unit. As soon as the result of this circular is known the Committee will further report.

LAUNCESTON.—At the last meeting of the Town Council a letter was read from the Brush Company intimating their intention of applying for a Provisional Order to supply electricity for public and private purposes within the borough.

LECTURES.—Lectures on electricity and some of its varied applications have recently been delivered at Ipswich by Mr. Notcutt, B.Sc., at Hamilton (N.B.) by Mr. D. Hunter, at Sunderland by Mr. W. H. Flood, and at Dublin by Mr. Rochfort.

LEICESTER.—Some time back the question of lighting the extensive premises of the Leicester Co-operative Society came up for discussion and met with some opposition, but at a meeting just held a proposal by Mr. Harrott that the Society should itself provide an installation was only lost by one vote.

MIDDLESBOROUGH.—Three firms, including Messrs. J. H. Holmes and Co., of Newcastle, have been asked to send in offers for executing the necessary works in connection with the lighting of the Municipal Buildings and Town Hall of Middesborough.

NANTWICH—At the last meeting of the Local Board the Clerk stated that he had only received about a dozen replies to the circular sent out by the Electric Lighting Committee. It was decided not to renew the electric light contract for the Local Board Offices during the summer months.

NEWPORT.—Prof. Robinson has sent in his report dealing with the subject of the lighting of this town by electricity. He deals with the installation of the light into many of the principal thoroughfares, and estimates the cost of replacing the gas at about £30,560, and the annual cost of maintenance at about £5,650.

PONSONBY HALL.—Ponsonby Hall, the ancient seat of the Stanleys, has been fitted up with the electric light, the current being generated by a turbine driven by water obtained from the river Calder.

PORTRUSH.—With regard to the electric lighting scheme which has been prepared by Mr. H. W. Blake, the Town Commissioners have, before taking action, decided to appoint a committee to obtain definite information as to the amount of support likely to be given by the ratepayers. Under the scheme the estimated cost of buildings, plant, apparatus, &c., will be £6,230, excluding the cost of the site. The working expenses are estimated to reach about £500 per annum, and the yearly revenue about £800, at a charge of 7d. per unit.

RANGOON.—The engineer of the Rangoon Municipality has submitted a report on the proposal made by the Manchester Edison-Swan Company to light the streets of Rangoon by electricity. The Company proposes to supply 1830 24-c.p. lamps for 38,000 rupees per annum, a concession being granted to them for fifty years. The Company further proposes paying 5 per cent of the profits to the Municipality in lieu of rent for the necessary sites for generating stations, &c.

READING.—The Electric Lighting Committee having reported the steps taken in regard to the Electric Lighting Provisional Order before the Board of Trade, the Town Council have adopted the Committee's report. Under the arrangements now made, if the Council determine to purchase the undertaking of the Electric Lighting Company provision is made for all accounts of capital, expenditure, &c., to be available. The Committee were anxious to embody a clause in the Provisional Order absolutely specifying what system of supply should be adopted, but the Board of Trade objected to this, while agreeing to the insertion of words giving the Local Authority an opportunity of being heard before the Board of Trade sanction to any particular system was obtained.

REDDITCH.—It has been decided to employ an expert to advise the Local Board on the subject of electric lighting, the general opinion being that gas being both expensive and inferior in the district, electric lighting would have a very fair chance of success.

SHOREDITCH.—Mr. A. M. Sillar has been appointed by the Vestry Instructor to the electric fitting class at the Technical Schools at a fee of 10s. 6d. per lesson. Some time back it was decided that the question of granting applications for hydraulic power should be discussed concurrently with the laying of mains for the electric light. The Hydraulic Power Company are, however, anxious to commence operations, and the whole question has, therefore, been referred back to the Paving and Sewers Committee for further discussion.

SOUTHAMPTON.—The Local Government Board have given their consent to the Town Council to borrow £400 for the purpose of lighting the Free Public Library by electricity.

SOUTHGATE.—The Local Board has voted a small sum, to be spent in the purchase of apparatus and materials for use in teaching the upper classes in the local schools electrical subjects.

SOUTHPORT.—Mr. E. Manville has sent in his report upon the most suitable system for lighting the district by electricity, upon which a difference of opinion arose amongst the members of the Electric Lighting Committee of the Town Council. He recommends the alternating-current transformer system, which is in confirmation with the original recommendation of the Borough Engineer.

WORCESTER.—A motion has been placed on the paper by a member of the Board of Guardians, to rescind the resolution recently come to declining to adopt the electric light at the workhouse. It is probable that an isolated plant will ultimately be put down to light the buildings.

YARMOUTH.—The Local Government Board have been asked to grant power to the Town Council to borrow £15,000 on account of the electric lighting scheme.

PATENT RECORD

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

April 12, 1893.

7,491. T. ODDY. London. Improvements in or relating to incandescent electric lamps.

7,509. J. COOPER. London. Improvements in incandescent electric lamps.

April 13, 1893.

7,559. W. H. SCOTT. Norwich. Combined switch and lamp holder.

7,561. I. A. TIMMIS. London. Improvements in electric railway signalling.

7,581. A. D. LEWIS and F. M. LEWIS. London. Improvements in electric arc lamps.

7,594. F. M. LYTE. London. Improvements in the electrolytical decomposition of chlorides and mixtures thereof, and in apparatus for the purpose.

April 14, 1893.

7,600. Sir D. L. SALOMONS, Bart. Tunbridge Wells. Improvements in electrical heating apparatus.

7,623. R. WOOD. London. Improvements in method of and apparatus for the conversion of the energy of electricity into that of light.

April 15, 1893.

7,687. N. D. J. O. GOLD. A new or improved conductor for electric and telephone wires.

7,697. H. ROBINSON. Manchester. Improvements in dynamo-electric and electric-dynamic machines.

7,702. J. T. JOHNSON. Glasgow. Improvements in electric signalling apparatus and systems for railways. (Jacob William Lattig and William Frederick Detwiller Pascoe, United States).*

7,711. P. SCHOOP. London. Improvements in electrical accumulators or secondary batteries.

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7,713. W. C. JOHNSON. London. Improved gland joint for electrical conductors.

7,714. A. J. H. WYATT. London. An improvement in electric targets.

April 17, 1893.

7,756. W. T. GIBBS and S. P. FRANCHOT. Ottawa. Improvements in the process of obtaining chlorates of the alkalies or of the alkaline earth metals by electricity.

7,758. E. KLOSS. London. Improvements in electric fire alarm apparatus.*

7,782. G. G. M. HARDINGHAM. London. Improvements in electric cables (the firm of Felten and Guilleaume, Germany).

April 18, 1893.

7,806. G. L. ANDERS and W. KOTTGEN. London. Improvements in portable telephones.

7,848. J. LEVI. London. Improved method of indicating telegraphic messages.

7,865. E. THOMPSON. London Lightning arresters and discharge protectors.*

8,866. E. THOMPSON. London. Lightning arresters.

April 19, 1893.

7,893. J. PATTERSON and JOHN SHAW AND CO. Glasgow. Improvements in junctions for underground conduits for electric wires.

7,897. W. JONES. Bristol. Improvements in galvanic batteries for utilising the waste.

7,935. E. V. BUCHET. London. Improvements in arc electric lamps.

April 20, 1893.

7,991. S. SIMPSON. Birmingham. Improvements in prepayment mechanism applicable to gas, electricity, and like meters.

8,004. E. DE PASS. London. Improvements in or connected with electro-motors, more especially applicable to the propulsion of vehicles. (Maxime Johannet and G. Dupont. France.)

8,035. H. D. CUNNINGHAM. London. Electroplating aluminum.

April, 21, 1893.

8,087. J. BROCKIE. London. Improvements in arc electric lamps.

April 22, 1893.

8,163. E. BAILEY and G. M. GORDON. London. Improvements in miners' electric safety lamps.

8,177. E. ANDREOLI. London. Improvements in electrolysis.

April 24, 1893.

8,197. W. ALDRED. Sheffield. Improvements in electric distribution and apparatus connected therewith.

April 25, 1893.

8,315. A. G. NEW and A. J. MAYNE. London. Improvement in switches for electric currents.

8,316. A. G. NEW and A. J. MAYNE. London. Improvements in the electrical propulsion of boats and vessels.

8,320. L. T. SMITH. London. Improvements in electric cigar lighters.*

8,330. M.E. COMPANY. London. Improvements in and relating to electric car brakes.*

8,331. E. TYER. London. Improvements in electrical lock and block apparatus for railway points and signals.

8,373. J. C. MEWBURN. London. Improvements in electric cigar lighters.

April 26, 1893.

8,427. L. B. MILLER and M. W. WOODS. London. Improvements in apparatus for regulating electric currents.

6,436. G. MARTIN. London. Improvements in controlling or regulating the supply of electricity and apparatus therefor.

April 27, 1893.

8,502. W. L. WISE. London. Improvements in electrical railways or tramways. (Alfred Diatto, Italy).*

April 28, 1893.

8,567. O. MARCH. London. Improvements in portable electric lamps.

8,571. H. C. W. EMERY. London. Improvements in or connected with cells for electric batteries.

8,600. A. J. GRAVIER. London. Improvements in continuous-current dynamo-electric and electro-dynamic machines.

April 29, 1893.

8,618. W. J. DAVY. London. Improvements in multiple change over mechanism for electric arc lamps.

8,649. J. MORRIS. Liverpool. Improvements in telegraph insulators.

8,654. W. J. DAVY. London. Improvements in electric arc lamps.

May 1, 1893.

8,712. J. FOY. London. The magneto-electric brace.

8,722. A. J. BOULT. London. Improvements in or relating to dynamos or electric motors. (O. Patin and L. Levavasseur, France.)

8,742. D. YOUNG. London. Improved methods of and apparatus for transmitting signals or electric impulses. (C. Cuttriss, United States.)*

May 2, 1893.

8,802. O. S. RUDDOCK. London. Improvements relating to the electric lighting of railway carriages and other vehicles.

8,803. H. LEHMANN. London. Improvements in electric accumulators or storage batteries, partly applicable as a constant primary element.*

8,812. C. D. ABEL. London. Electrical apparatus for raising the shutters of telephone indicators (Société Générale des Téléphones Réseaux Téléphoniques et Constructions Electriques, France).

May 3, 1893.

8,901. E. J. P. MERCADIER and J. M. ANIZAN. London. Improvements in microphones.

8,908. M. GUTHRIE. London. Improvements in apparatus for the electrolytical decomposition of brine and other liquids.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1892.

3,887. STUART. Sending fire signals over telephone wires.

7,029. HARDINGHAM (Felton and Guilleaume). Electric cables.

7,226. HOHO and LAGRANGE. Electric treatment of metal, &c.

7,492. OPPENHEIMER. Electric bells.

7,826. FROGGATT. Electric lamp shades.

7,833. WALKER and HAMPSHIRE. Electrical metronome.

8,211. SMITH and WILSON. Stopping or controlling electrical engines, &c.

8,385. TAYLOR. Electricity meters.

8,537. LANGDON. Electric switch.

8,743. SHIELS. Electric wire couplings.

9,148. EBBUTT and VERITY. Swing joints for electric light fittings.

9,185. SHIELS. Electric wire couplings.

9,500. MUNRO and MCFARLANE. Electric switches.

9,536. ALLISON (Mailloux). Electric distribution.

9,850. PICKUP and others. Fans operated by electricity.

10,388. FREUND and BRISTOL. Secondary batteries.

10,430. WOOD (Jefferson and another). Electrical insulating sheet.

10,557. MCNEILL and AITKEN. Electrical insulating sheet.

10,706. SMITH and GRANVILLE. Electric telegraphic communication

10,818. BOLLÉ (Jifferson). Electrical conduit.

11,087. WISE (Rosati and others). Galvanic batteries.

16,142. HOFFGAARD (Fyrd). Telegraphic receiving instruments.

16,624. FAIRALL. Electricity meters, &c.

19,690. ENHOLM. Incandescence electric light circuits.

1893.

538. MITCHELL. Electro-magnetically heated receptacles, &c.

2,600. HADDAN (Didreux). Electric incandescent lamp.

2,696. NEWTON (Gray). Writing telegraphs.

3,200. SCHOMBURG. Electric conducting wires.

3,398. GENTZSCH and others. Electrical insulating material.

3,461. NESTLER. Writing desk, &c., for telephones.

4,363. THOMPSON (Bates). Electric railways.

4,869. GIBBS and FRANCHOT. Obtaining chlorates of the alkalis by electrolysis.

5,339. LUNDELL and JOHNSON. Electric motors.

5,486. MESTON. Dynamo-electric machines.

COMPANIES' MEETINGS AND REPORTS.

Western and Brazilian Telegraph Company (Limited).

The twenty-fifth ordinary general meeting of this Company was held yesterday (Thursday) at Winchester House, E.C., Mr. W. S. Andrews (Chairman) presiding.

The SECRETARY (Mr. R. M. Cunningham) read the notice convening the meeting, and the minutes of the last meeting.

The CHAIRMAN said: Gentlemen, you have all had copies of the report and accounts, and I presume, you will take them as read. I am sorry to say that it is my melancholy task to-day to mention the death of a greatly esteemed gentleman, and one of the leading men in the telegraphic world, namely, Sir James Anderson, who was Chairman of the Brazilian Submarine Company with which, as you know, we are very intimately connected. Sir James Anderson was a very good friend of ours—in fact, I think he was a good friend to everybody. (Hear, hear.) He was a mellow, kindly-natured man who made troops of friends without, as I believe, making a single enemy. He was a man of considerable ability, and his loss will be a severe one, not only to his many personal friends whom he always possessed, but to the telegraphic world in general. Gentlemen, I must also mention something else of a personal nature before coming to the accounts. I daresay you notice the absence of our friend, Mr. Coppen, who was elected by the shareholders to a seat on the Board. He was unfortunately taken ill recently, and has had to go abroad for the benefit of his health. Before leaving, however, the accounts were in a rather forward state, and we were enabled to foreshadow pretty accurately what is being laid before you to-day, and Mr. Coppen desired me to say that he fully concurred in the policy which we were bringing before you in the report. After those preliminary remarks, I will now deal as usual with the receipts of the Company for the last half of 1892. The income was £86,954. 11s. 2d. against £92,345. 4s. 7d. for the corresponding half, showing a decrease of £5,390. 13s. 5d. on the six months. Considering the depres-

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sion of commercial affairs in South America—not merely in one State, but in all the States—the condition of the exchange, and the additional competition we have been subjected to from October 5th to December 27th in last half-year, it appears to me that the figures, on the whole, are really more satisfactory than we could have anticipated. On the other side, the expenses are an encouraging feature, showing, as they do, a reduction on the total amount, partly owing to exceptional causes. They amount to £37,165. 11s. 5d., against £38,404. 5s. 1d., or a decrease of £1,238. 13s. 8d. Of course those totals are made up of a great many items. In abstract "A," for instance, there is an increase of £1,866. The expenses incurred under the head of salaries and wages in Brazil, where the revenue is earned, show an aggregate growth of £1,143, due to many causes. Our local superintendent and representative received an increase, and there is an item of £500 which will not occur again. There is also £575 for additional clerkage, duplex, promotion on account of long service, and certain small local additions owing to the lower value of the milreis in which those particular servants are employed. Then there is a sum of £870 caused by the changes in the staff, travelling expenses, and so on, which were unavoidable; and a small increase in the medical expenses and gas make up the total. On the other hand, there is a decrease of £743, mainly on the maintenance of land lines and stores and apparatus. There are small decreases in stationery and law and insurance, making up the remainder. The net result of the increase under abstract A is £1,886. The expenses of the ships in abstract B show a decrease under all the heads, the "Norseman" of £2,331 and the "Viking" of £793. As the ships were a shorter time at sea less coal was consumed, and the coal was purchased at a lower price. The "Viking" was under repair part of the period, so that her expenses were not running on, and there were some exceptional causes besides, giving as the result a total saving of £3,124. Under abstract C. the London expenses, you will find a total increase for salaries, rents, stationery, stamps, and telegrams amounting to £127. The net outcome of the whole thing is a reduction of £1,238 in the expenses of the Company for the past half-year. If we now take the balance of the revenue, £49,788, together with the sum brought from the June half-year, £1,662. plus the dividend from the Platino Company, £7,387, because I am glad to say we have got our dividends back from the Platino, we reach a total of £58,838. Against this there are charges for the debenture interest £12,426, redemption £6,674, and reserve £15,000, together £34,100. This leaves us £24,738, and we propose to recommend the declaration of a dividend of 1½ per cent. for the half-year, at the rate of 3 per cent. per annum. This will take about £21,908, leaving £2,829 to be carried forward. Now, I am glad to say that we seem to have reached a demarcation line, so to say, in the history of this concern. We have been aiming at particular things, including the duplication of our system from Pernambuco to Buenos Ayres, and we have succeeded in getting that done. It was a necessary preliminary to getting rid, as we hope to do, of one of your repairing ships and of the consequent expense. After we had obtained the duplex and had removed all the cable we had in deep water, we saw our way to ordering the new ship we have just sent out. It has been built upon the best lines, with the highest speed and working capacity, and we trust she will enable us to maintain our system more economically. At the present moment, as you know, we have the old "Norseman," the "Viking," and the new "Norseman." The new ship was built with the special object of keeping our whole system in a state of efficiency without the aid of a second ship. She has now gone out, and on her arrival the "Viking"—which is the vessel at present on the station—will be laid up. The ship will be maintained in good condition, a captain and engineer will be retained, and in the event of an exceptional emergency, which we do not anticipate, she would be ready almost at once to go to sea. Well, we are going to give this policy a trial, although not too long a one. The "Viking" will cost very little when laid up, and we expect that the result will be satisfactory, and that we shall be enabled to do away with the large expenditure necessarily attendant upon keeping two ships instead of one. The "Viking" is in first-rate order. She has new boilers and excellent machinery, and if we can see our way to do without her it is our intention to dispose of her at the best price possible. The former "Norseman" is actually laid up, and we are only awaiting an opportunity to sell her or to obtain a charter for her. She is a fine vessel, and can handle cables in very deep water. There is, however, one circumstance against it, and it is a strong one, unfortunately. I refer to the present state of the market. We can only hold on and endeavour to do the best when an opportunity arises. Well, gentlemen, we told you that if the revenue continued fairly satisfactory, and especially if the exchanges were good, we should be enabled to meet our liabilities without issuing any debentures. As a matter of fact, we have so far been able to do so. Neither circumstances nor exchange have been very propitious, but, nevertheless, we have managed to get through. I daresay some gentlemen have noticed that we have put £15,000 to reserve fund. I know that some gentlemen object to the amounts we place to reserve, but in this case, again, it has been Hobson's choice. You had approved of the loops policy and the ship policy, and it is the carrying out of these things which, as all of you know, has required the money for the payment of them. Our accounts are all straight up to December last, but we knew there were some still to come in which would have to be provided for—mostly on account of the new ship, which is going to bring about the big economy I have mentioned. Of course, we have no shares to issue but only debentures. You are aware that it was decided we should avoid issuing these debentures if possible, inasmuch as they would only put permanently a charge between the ordinary and deferred shareholders and a dividend, and therefore we had to take from income the £15,000 I have named to provide for the engagements we had entered into, as we believe, for your future benefit. We have scraped through, notwithstanding the fact that the conditions have not been as good as we anticipated they would be. It was then quite uncertain to what extent the competition, then threatened, would deplete our revenue. We told you we should do our best, and we thought that, owing to the enlightened assistance of you, gentlemen—because we could not have done it without that—owing to this, and to the looping of the cables, and the provision of the duplex, and all the various other arrangements made, we should be able to hold our own. Well, looking at the traffic of 1892, I think it will be admitted that we have fairly held our own there; and if we look at the current traffics, those published from time to time, I think you will say that we are holding our own still in 1893. I confess, personally, that I entertain the view that we are doing very well under the circumstances. We are not losing what we might reasonably have anticipated we should have lost, and our revenue is keeping up, not merely in face of this competition, but it is keeping up in face of the low exchange also. The exchange has been unusually low, and presses upon us very severely. I think I may go as far as to say that, notwithstanding all this competition, all we need, even with our present business—and you know it is a business we are getting under depression, and that the state of things in the River Plate and in Brazil is very unsatisfactory, and that trade is comparatively inactive—well, even with the trade we are getting under these circumstances, if the exchange were only, I will not say at par, but fairly favourable, our Company would be enabled to pay the dividends which it did recently pay. All that we want at the present time—provided, of course, nothing of an exceptional character arises, which cannot be foreseen—is a rise in the rate of exchange, and given that, there is no earthly reason why this Company should not be as prosperous as in those days which we talked of as showing abnormal traffics. My impression is that we should then get back somewhere to that position, at all events in the money. They say there is a grand coffee-crop in Brazil, and it is withdrawing a considerable amount of currency, which Brazil at the same time destroys, and by that means we hope exchange may be improved. Then, if exchange does improve, there may take place a great recovery in the commercial affairs of the young and enterprising nations of South America. They are big nations, and are always developing and increasing their commerce. In fact, we are dealing here with a growing quantity. Now, gentlemen, I do not think I need trouble you with further observations, and therefore I beg to move—

"That the report and accounts to the 31st December, 1892, be and are hereby approved and adopted, and that a dividend on the ordinary shares of 4s. 6d. a share, free of income tax, making with the interim dividend 2½ per cent. for the year 1892, be and is hereby declared payable on the 12th instant."

Mr. C. W. EARLE seconded the resolution.

In reply to Mr. CLARKE,

The CHAIRMAN said the £6,000 from the Brazilian Submarine Company was included in the accounts.

In reply to several shareholders,

The CHAIRMAN said: The figures give the gross revenue after deducting the exchange. I omitted to mention that the new ship was paid for out of the balance of the reserve that we brought over to this current period.

The resolution was then carried unanimously.

Lord RICHARD BROWNE proposed the re-election as a director of Mr. W. S. Andrews.

Major WOOD (Managing Director), in seconding the resolution, said the Chairman gave an immense amount of time and trouble to the affairs of the Company, and brought to bear upon their business that practical knowledge which was perfectly invaluable.

The motion was agreed to.

The CHAIRMAN then proposed the re-election of Mr. J. Coppen as a Director.

Mr. D. H. GOODSALL seconded, and it was passed.

On the motion of Mr. ELLIS, seconded by Mr. PETO, the retiring auditors—Messrs. Turquand, Youngs, Weise, Bishop, and Clarke, and Messrs. Deloitte, Dever, Griffiths and Co., were re-appointed.

A vote of thanks to the Chairman, Directors, Managing Director, Secretary, and Staff, proposed by Mr. PETO, and seconded by Mr. MACHELL, brought the proceedings to a close.

Elmore's (French) Copper Company (Limited).

An adjourned general meeting of this Company was held on Monday last at Winchester House, E.C., Major C. Jones presiding.

The meeting was called for the purpose of obtaining the shareholders' consent to the Company going into voluntary liquidation, and to enable Mr. Duncan (Receiver) to enter into an agreement for the sale of the factory and business in France to M. Secrétan, as representing a French Company, on the lines set forth in the scheme submitted to the shareholders a few weeks since, the chief points of which will be found in *The Electrician*, of April 14th.

Mr. DUNCAN said the arrangement was not all that he could have wished, but it was the best he could obtain, on account of the requirements of French law. With regard to the creditors, the debenture-holders would be asked to extend their claim for five years, and the Elmore's Foreign and Colonial Company to postpone their second mortgage and make it a third mortgage, in order that the creditors who had securities might be satisfied by being put in the position of second mortgage-holders.

Mr. WOOD (Chairman of the shareholders' Committee) moved a resolution agreeing to the sale, and stated that the shareholders would now have a chance of eventually getting a return of their capital.

The motion was carried.

Resolutions for the voluntary liquidation of the Company were agreed to, and Mr. Pixley was appointed liquidator.

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Elmore's German and Austro-Hungarian Metal Company (Limited).

The second annual general meeting of this Company was held on Wednesday last week, at Winchester House, Old Broad-street, E.C., Mr. James Rock presiding.

The SECRETARY read the notice convening the meeting.

The CHAIRMAN said: The meeting that day was one of great importance to the future of the Company. It was for them to say whether they should press on with the enterprise. He unhesitatingly said they ought to go on with it, and be content with nothing less than a complete commercial success. From a practical point of view, their methods of manufacture, under the able management of Mr. Preschlin (their manager at Schladern), had made extraordinary progress during the last three months. He was not at liberty to speak fully upon all points, from considerations of prudence, but it was his conviction that if the same conditions which they now had at their works had existed a year or two ago, they would not be asking for money that day, and the whole Elmore enterprise might have had a very different complexion from that which it then had. He claimed for their Company a distinct individuality. They were not mixed up with any other company, but had established a firm basis for success in the future, so far as it depended upon a well-organised manufactory in which the methods of working had been so developed as largely to increase the accuracy of the work and to diminish the cost of production. The year 1892 was one of difficulties. For many months they were kept out of the mandrils which had been ordered from the English Company, and the remainder of the year was chiefly employed in making mandrils for themselves. The result of the only appeal for funds made to their shareholders was shown by the report they had. By the failure of the issue of preference shares the Board was placed in a very difficult position—the last instalment of the purchase of the property at Schladern was nearly due, and there were no funds in hand to meet it or to carry on the works. In this emergency they applied to Mr. Berger (the vendor of the property) to allow further time for payment, and he extended the time till November next. Some money must be provided immediately, or the works must be closed. The debts owing to outside creditors by the German Company on December 31st were small, and there was then cash in hand sufficient to pay them.

The CHAIRMAN then entered into a detailed account of the "mandril troubles" the Company had passed through and surmounted. Continuing, he said their present funds would only carry them on a week or ten days longer. They proposed to arrange for an issue of mortgage debentures secured upon the property at Schladern, but this would take time and would not meet the present emergency. They had £3,000 of debentures charged upon the property of the Company, including £50,000 in shares of the Company in Germany, and the Directors asked the shareholders to subscribe for these. They were secured upon all the property of the German and Austro-Hungarian Metal Company. £1,000 would enable them to go on till the end of this month; £2,000 would carry them on till the end of June, and give them time to turn round and endeavour to find the larger sum required to complete the purchase of the property; with £3,000 they could press on the business with greater probability of early success. He then moved the adoption of the report and accounts.

Lieut.-General G. H. FRASER seconded the motion.

General BEADLE said they were asked to subscribe a small sum in order to put what really appeared to be a very promising young factory into better working order; but before doing so they wanted to understand a little more about the Company. The Board had gone to allotment with an insufficient amount of capital subscribed. Seventy-five thousand shares were offered to the public under the promises of a prospectus every paragraph of which appeared to him to be unfair and misleading. The prospectus said that they were to commence with a working capital of £100,000, but only £50,000 of the shares had been applied for, and therefore the Board should have returned the money. The result was that they were now compelled to raise more money from the public. No doubt steps had been taken to bolster up the shares, and the whole of that matter would have to be gone into most carefully by a committee. He concluded by moving an amendment—

"That this meeting be adjourned, and a committee of shareholders be appointed to report generally."

He thought it right that the affairs connected with the Company should be inquired into.

Mr. GLADSTONE seconded the amendment.

Mr. F. L. RAWSON stated that the Directors of the Austro-Hungarian Company fixed £50,000 as the minimum amount for going to allotment before the Company came out.

The CHAIRMAN said the important question was as to the working capital. If General Beadle would look at the prospectus he would see that it was stated that if the whole of the capital were subscribed there would be £100,000 for working capital; but, unfortunately, that amount was not subscribed. Before the prospectus was issued the Board decided, on the motion of Mr. John Morris, that they would not go to allotment unless they had as much working capital as the French Company, namely, £50,000, which they thought was sufficient. If the amendment were carried, and the meeting were adjourned until May 31st, their works would be closed for want of funds.

Mr. F. L. RAWSON suggested that the best course to pursue was for the Board to issue £5,000 of debenture stock, charged upon the property in Germany.

The CHAIRMAN stated that the Board had no objection to an investigation of the affairs of the Company, but unless money were found in ten days the works would have to be stopped.

The amendment was then put and lost, and the adoption of the report was agreed to.

On the motion of Mr. McFARLAN, Mr. Rock was re-elected a Director of the Company.

The retiring auditors were re-appointed, and a vote of thanks to the Chairman terminated the proceedings.

West India and Panama Telegraph Company (Limited).

The following is the report of the Directors for the half-year ended December 31st last, to be submitted to the thirty-second ordinary general meeting to be held at Winchester House, E.C., on Tuesday, the 16th inst.:—

The amount to the credit of revenue is £38,358. 11s. 9d., against £36,141. 2s. 8d. for the corresponding half-year of 1891, and the expenses have been £25,155. 11s. 5d., against £25,296. 3s. 11d. for the same period in 1891, leaving a balance of £13,203. 0s. 4d., which, with £3,704. 15s. 2d. brought from last account, makes a total of £16,907. 15s. 6d. Of this sum the Directors have placed £1,500 to reserve, leaving an available balance of £15,407. 15s. 6d., with which it is proposed to deal as follows:—

	£	s.	d.
First Preference shares—			
Dividend, six months to Dec. 31st, 6s. per share ...	10,368	18	8
Second Preference shares—			
Dividend, six months to Dec, 31st, 6s. per share ..	1,400	14	0
Ordinary shares—			
6d. per share (free of income-tax)	2,208	0	6
Balance to current half-year's account	1,430	3	0
	15,407	15	6

The traffic receipts for the six months show an increase of £2,065. 7s. 1d., as compared with the corresponding period, which is solely due to greater activity in West India trade. The cost of repairs to cables amounted this half-year to £12,013. 7s. 3d., as compared with £15,055. 18s. 2d. for the corresponding period.

The Company's s.s. "Grappler," after having been repaired and fitted with a new boiler in London, arrived in the West Indies with a cargo of 256 nautical miles of cable for stock on the 23rd ultimo.

Since the close of the half-year the Directors have to report that the colony of Trinidad, whose ten years' term of subsidy of £6,000 per annum expired on December 31st last, has reduced its grant to £3,000 for 1893, and that St. Lucia has also reduced its subsidy from £800 to £500 for the current year.

The Directors feel that these curtailments of subsidies, following as they do so shortly after the Company has made the sacrifice of largely reducing rates, cannot be looked upon but as a heavy blow to the anticipations of some improvement in the return on the capital invested in an enterprise which, for the last twenty years, has done so much for the commerce, the safety, and the administrative economies of the West India Colonies, and so little for the shareholders.

Mr. William Andrews retires at this meeting, and offers himself for re-election. Mr. John George Griffiths, the auditor, also retires, and offers himself for re-election.

The following circular accompanies the report:—

The Directors regret to announce the death of their esteemed colleague, Sir James Anderson, which has occurred since the accompanying report was in print. For the reasons stated in the Directors' report presented to the last ordinary general meeting, it is not proposed to fill up the vacancy in the Board thus occasioned. As, however, the Articles of Association fix the minimum of Directors at six, and there now remain but five Directors on the Board, it is necessary to obtain the sanction of the shareholders in general meeting to an alteration of this minimum. It is therefore intended at the extraordinary general meeting, of which notice is endorsed hereon, to propose to the shareholders that the minimum number of Directors shall, until otherwise determined, be four instead of six.

LEGAL INTELLIGENCE.

Ipswich Electricity Supply Company (Limited) v. Iliffe.

On Tuesday, in the Queen's Bench Division, before Justices Cave and Lawrence, an application was made by Mr. Ashton Cross on behalf of Messrs. Bolton and Sons, Birmingham, judgment creditors of the Acme Electrical Works, which have been taken over by the Ipswich Company, the plaintiffs in this action. Mr. Justice Mathew, in chambers, had made an order in April last ordering the Receivers of the Company to pay certain moneys to the applicants subject to the satisfaction of any prior rights, and introducing certain other limitations which the applicants wished to have removed. Mr. Cross said there was no evidence given of any prior charges or rights, and the manner in which the receivers were appointed made it clear that the real object was to protect the works and goods of the Company from the creditors. Messrs. Bolton and Sons had supplied goods to the Acme Electric Works, and they were not made aware of the fact that the works had been transferred to anybody else until quite recently, when they were informed that Messrs. Teague and Aiken had been appointed Receivers to the Company, in consequence of internal disputes between the partners. Mr. Iliffe had been the original owner of the works, but the Ipswich Electricity Supply Company had been formed, with a capital of £100, of which £7 had been subscribed, to purchase them, the consideration, as disclosed by the agree-

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ments filed at Somerset House, being £30,000, to be paid by the allotment to the vendor or his nominees of £10,000 in debentures, £10,000 in Five per Cent. Preference Shares, and £10,000 in ordinary shares, the sale to take effect as from August 1st. Arrangements were made, however, whereby the works should still be carried on in the same name—that of the Acme Electric Works. The debt of Messrs. Bolton was about £99, and they obtained judgment against the Acme Electrical Works; but when they tried to levy execution they were met by the statement that an action had been brought by the Ipswich Company against Mr. Iliffe, the vendor, and that Messrs. Teague and Aiken had been appointed joint interim Receivers and managers. There was another subsequent order, by which a gentleman, who appeared to be a judgment creditor of Mr. Iliffe, had appointed himself Receiver in regard to Mr. Iliffe's interest in the property. Applicants' writ was issued against the Acme Works on March 1st, judgment obtained on March 10th, and, the Receivers meeting the claim in the manner stated, after some litigation an order was made on April 7th, "that the Receivers hold the goods until further order, the plaintiffs (Messrs. Bolton and Sons, the execution creditors) to apply forthwith to the Court to direct the Receivers to pay the judgment debt." The application was made, and the result was the order of Mr. Justice Mathew of April 26th. His (Mr. Cross's) application was that the debt should be paid within seven days, or that he should have leave to issue execution.

Mr. JUSTICE CAVE said they could not fix a time within which payment must be made, and there being no opposition from the Receivers, Mr. Justice Mathew's order was amended, so that the applicants have a charge on the moneys of the Company subject to any prior charges, the Receivers to pass their accounts within a reasonable time.

Suren, Hartman and Co. v. W. T. Henley's Telegraph Works Company, Limited.

In the Court of Appeal, on Monday, before Lords Justices Lindley, Bowen and Kay, an appeal from a judgment of Mr. Justice Stirling, on behalf of the defendants in this action was heard on Monday last. The matter in dispute was as to the construction of a clause in an agreement between the parties. In the year 1886, the International Cable Company was formed to lay down submarine cables, that Company having obtained a concession from the Government of Portugal for leave to lay down cables to Canada *via* the Azores, the concession and monopoly to last for twenty years. On November 2, 1886, the International Cable Company entered into a contract with the defendant Company under which the latter were to manufacture a large amount of cable. Soon after this a contract was entered into between the plaintiffs and the defendants, the undertaking being that the plaintiffs should take 500 shares in the International Cable Company, paying £250 on application and £250 on allotment, but that the defendants should indemnify the plaintiffs against the payment of any further calls on those shares, and should within two months of receiving an order to manufacture all or any of the cables repay the plaintiffs the full amount which they had paid upon the shares, either in cash or fully paid-up shares. The order to manufacture had never been given, and the plaintiffs sought to recover the £500 which they had paid. The defendants contended that their payment of the money was to be contingent on the order being given for the manufacture of the cables, and as no such order was ever given they were not liable. Mr. Justice Stirling held that they were, and defendants appealed from that judgment.

Mr. RAM, for the plaintiffs, contended that by the terms of the contract they were not called upon to repay the £500 on the shares unless they got the order for the manufacture of the cables: and in reply to the Lords Justices as to the consideration which the plaintiffs were to receive for their payment, said it was a joint risk entered into in the expectation of considerable profits, Messrs. Suren, Hartman, and Co. expecting to supply the wire required for the cable.

Lord Justice LINDLEY said it was obvious that the plaintiffs took the shares simply as the trustees for the defendants, and at once handed them over. The clause as to the repayment within two months of the order being given was merely a statement of the time for the repayment and a stipulation that the defendants, in the event of an order being given, should have the option of making the repayment either in cash or in fully paid-up shares. He could not for the life of him see how the defendants could on the agreement raise the contention which they did. It would be monstrous if they were not to pay the £500.

Lords Justices BOWEN and KAY concurred, and the appeal was dismissed with costs.

Gartside v. Shippey.

At the Manchester Spring Assizes, before Mr. Justice Collins, without a jury, an action was brought to recover the sum of £56. The plaintiff was Mr. Henry Gartside, brewer, of Stalybridge, and the defendant was Mr. Arthur Shippey, electrical engineer. The parties were interested in the success of a patent brake and starter, and the plaintiff agreed that in the event of the Manchester Carriage and Tramways Company adopting it on their tramcars he would pay the defendant £1,000. The patent was tested, and was said to be a complete failure. On one occasion the plaintiff lent the defendant £56, and this he now asked to be repaid. The defence was that the money was to be repaid out of the problematical £1,000. This the plaintiff denied; he said the defendant asked that the arrangement for repayment might be so, but he declined to allow that, and the defendant accepted the loan on his own personal account. Mr. Shippey claimed that his patent had not proved a failure, and that, therefore, he was entitled to £1,000 from the plaintiff, and for this sum he counter-claimed.

The Judge found for the plaintiff on both the claim and counter-claim.

NEW COMPANIES, STATUTORY RETURNS, &c.

[In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in "The Electrician" Electrical Trades' Directory and Handbook, 1893, pages 320-348, &c., &c.]

COLNE ENGINEERING COMPANY (LIMITED).—This Company was registered on the 5th inst. with a capital of £10,000 in £1 shares, to carry on the business of mechanical and electrical engineers, electricians, millwrights, art-metal workers, &c., carried on at Twickenham.

ROLLASON'S WIND MOTOR COMPANY (LIMITED).—This Company was registered on the 5th inst., with a capital of £35,000 in £1 shares, to carry on the business of electricians, mechanical and electrical engineers, suppliers of electricity for the purposes of light, heat, motive power, or otherwise, and manufacturers of and dealers in all electrical apparatus.

ST. NICOLAS CONSTRUCTION COMPANY (LIMITED).—This Company was registered on the 2nd inst., with a capital of £40,000, divided into 2,000 shares of £20 each, to carry on the manufacture and sale of electric, telegraphic, and scientific instruments, the erection, maintenance, sale, and letting on hire, of electrical, engineering, and other goods and apparatus connected with the production of light, heat, sound, and motive power, and to carry on the business of electricians, electrical contractors, electrical, mechanical, chemical, and metallurgical engineers, suppliers of electricity, and manufacturers of and dealers in all electrical apparatus.

SAXBY AND FARMER (LIMITED).—This Company was registered on the 4th inst., with a capital of £25,000, in £10 shares, to carry on the business hitherto carried on by Messrs. Saxby and Farmer, and generally to carry on the business of manufacturers of railway signals, locking apparatus and safety appliances, mechanical and electrical engineers, electricians, iron and brass founders, &c.

THOMAS ROBINSON AND SON (LIMITED).—Registered with a capital of £120,000 in £10 shares, to carry on business as engineers, boiler makers, millwrights, machinists, &c., at the railway works, Rochdale.

BRITISH TANNING COMPANY (LIMITED).—A resolution was passed at a meeting held on May 3rd at Winchester House that the Company be wound up, and Mr. John Dalgleish, chartered accountant, of 8, Old Jewry, E.C., was appointed liquidator.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED AND REDUCED).—A petition for confirming a resolution reducing the capital of this Company has been presented to the High Court of Justice.

ELECTRICAL SUPPLIES AND FITTINGS COMPANY (LIMITED).—The petition of the Electrical Company (Limited), directed to be adjourned from April 11th, will be heard on Wednesday next, May 17th, when the Court will be asked for an order continuing the voluntary winding up under the supervision of the Court.

INDIA-RUBBER, GUTTA-PERCHA AND TELEGRAPH WORKS COMPANY (LIMITED).—The annual return of this Company, made up to February 28th, has been filed recently. The whole nominal capital of £500,000, in £10 shares, has been taken up, the full amount called, and all calls paid.

LONDON METALLURGICAL COMPANY (LIMITED).—A petition for the winding-up of this Company was presented on May 6th, and is down for hearing at the Royal Courts of Justice on Wednesday next, the 17th inst.

NEW BRITISH ELECTRIC INSTALLATION CONTRACTORS (LIMITED).—At extraordinary general meetings, held at 50, Foregate-street, Worcester, on March 11th and April 8th, the following special resolution was duly passed and confirmed:—"That this meeting authorises the issue of £3,500 in £6 per Cent. First Mortgage Debentures, redeemable in seven years from the 25th day of March, 1893, such debenture issue to form part of, and not an addition to, the amount of capital authorised by this clause, viz., £25,000."

NEW TELEPHONE COMPANY (LIMITED).—The annual return of this Company, made up to January 14th, has been filed. The nominal capital is £750,000, divided into 74,700 shares of £10 each and 3,000 shares of £1 each. 74,695 £10 and all the £1 shares have been taken up, and upon 1,000 £10 shares the full amount has been called; upon the £1 shares the full amounts have been called, and upon 75,200 £10 shares £4 per share has been called. The calls paid amount to £304,736, £1,064 is in arrears, 500 £10 shares have been issued as fully paid, and £10 has been paid on five forfeited shares.

NOTTING HILL ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of this Company, made up to April 10th, has been filed. The nominal capital is £100,000, divided into 6,452 ordinary, 550 founders', and 2,998 ordinary preference shares of £10 each. All the ordinary and founders' and 816 of the ordinary preference shares have been taken up, the full amounts called, and all calls (£78,180) paid.

PORTLAND ELECTRIC LIGHT COMPANY (LIMITED).—In response to official inquiries, Messrs. Strode and Co. state that no business has ever been carried on by the Company, and that no opposition will be raised to the striking of its name off the register of joint-stock companies. The Company was registered on November 30, 1887, with a capital of £45,000, in £5 shares, to carry on the general business of an electric light and power company, but the shares taken up by the signatories to the Memorandum of Association were the only ones ever subscribed for.

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SHEFFIELD TELEPHONE EXCHANGE AND ELECTRIC LIGHT COMPANY (LIMITED).—A meeting is to be held at the office of the Sheffield Electric Light and Power Company (Limited), Commercial-street, Sheffield, on June 12th, at 11, to receive an account of the winding up.

TAYLER-SMITH ELECTRIC COMPANY (LIMITED).—The first annual return of this Company, made up to August 3, 1892, has been filed. Out of a nominal capital of £6,000, divided into 300 preference and 300 ordinary shares of £10 each, 299 preference and all the ordinary shares were taken up, of which the ordinary shares were issued as fully paid. Upon the preference shares £7. 10s. per share has been called, resulting in the payment of £2,715 (including calls paid in advance), leaving £132. 10s. in arrears. The annual return for 1893, made up to April 1st, has also been filed, and shows that the full amount has been called on the preference shares, resulting in the payment of £2,980.

THOMPSON, RITCHIE AND CO. (LIMITED).—The annual return of this Company, made up to April 13th, has been filed. The nominal capital is £5,000, divided into 200 preference and 300 ordinary shares of £10 each. All the preference and 140 of the ordinary shares have been taken up, of which 100 preference and 70 ordinary shares have been issued as fully paid to Arthur S. Grove, the vendor. Upon the remaining 100 preference and 70 ordinary shares the full amounts have been called and all calls (£1,700) paid.

CITY NOTES, &c.

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).—Notice is given of the drawing of 106 of the Four per Cent. Mortgage Debenture Bonds of £100 each of this Company, which will be paid off at par on July 1st at Parr's Banking Company and the Alliance Bank (Limited), Batholomew-lane, E.C.

AFRICAN TRANSCONTINENTAL TELEGRAPH COMPANY (LIMITED).—The following letter has appeared in *The Times*:—"The Central African and Zoutpansberg Exploration Company (Limited), Portland House, Basinghall-street, London, E.C. In a recent issue I notice that a general meeting has been held of the African Transcontinental Telegraph Company, at which it was stated that material was being sent to the Chinde for the purpose of constructing a line between Fort Salisbury and Zomba, presumably across Portuguese territory. In article XI. of the Anglo-Portuguese Treaty of June 11, 1891, we find as follows:—'It is further understood that in the above-named districts each Power shall have the right, so far as may be reasonably required for the purpose of communication between territories under the influence of the same Power, to construct roads, railways, bridges, and telegraph lines across the district reserved to the other. The two Powers shall have the right of acquiring in these districts, on reasonable conditions, the land necessary for such objects, and shall receive all other requisite facilities. Portugal shall have the same rights in the British territory on the banks of the Shiré and in the English territory comprised between the Portuguese territory and the banks of Lake Nyassa. Any railway so constructed by one Power on the territory of the other shall be subject to local regulations and laws agreed upon between the two Governments, and, in case of differences of opinion, subject to arbitration as hereinafter mentioned.' Surely this does not mean that, without any warning, the workmen of the Transcontinental Company are to land where they like in Portuguese territory, without any previous intimation, and proceed to erect a telegraph line, nor yet that, if a line is about to exist across this territory, it will be permitted to construct another and a rival line. The Portuguese Government has under construction, from Sena to Sete, a line of telegraphs, and a concession has been granted to the Companhia da Zambesia to construct certain telegraph lines in the province of Quilimane, and among these lines is that one destined to connect the lines coming to the Portuguese frontier, either on the north or south side, with those on the opposite frontier. If that concession is carried out, the Transcontinental Telegraph Company will be without a reason for demanding the right to enter upon or traverse Portuguese territory. There is no desire on the part of the Companhia da Zambesia, or those to whom it has intrusted the construction of the telegraph lines in question, to oppose or be hostile to the Transcontinental Telegraph Company—it wishes to work in harmony with them and to aid in the undertaking; but it maintains, and will maintain, that the right to construct the section of the line across Portuguese Zambesia is theirs, and, as they intend to exercise it immediately, there is no reasonable condition unfulfilled which, by Article XI. of the treaty, would entitle anyone to construct a competing line.—V. Lovett Cameron, Chairman, London Committee, Companhia da Zambesia.

CALLS DUE.—*May 15:* BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED), £1 on 10,000 new ordinary £3 shares, and 10s. on 15,000 new 6 per cent. preference shares of £2 each; CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED), final £2 on 20,000 Accumulative Six per Cent. preference shares of £10 each; ELECTRIC CONSTRUCTION CORPORATION (LIMITED), final £3 per bond on 10,000 Six per cent Second Mortgage Debenture Bonds of £10 each.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended May 7th were £793, as against £802 for the corresponding period of last year, being a decrease of £9. The total receipts for the half-year amount to £16,153, against £14,898 in the corresponding period of 1892, being an increase of £1,255.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—At a special Board meeting on Tuesday, it was resolved, subject to audit, that dividends at the rate of 6 per cent. per annum on the preference and 2 per cent. per annum on the ordinary shares, both less income-tax, should be declared for the year ended March 31st at the approaching annual general meeting of the shareholders. The transfer books will be closed from the 19th to the 27th instant, both inclusive.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—In addition to the death of their Chairman (Sir James Anderson), the Directors and staff of this Company have to deplore the loss of Mr. Herbert Renny Duke (for many years auditor of the Company's accounts), who died very suddenly on May 3rd, and was buried at Shooter's-hill on Saturday last, the 6th instant.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this Company for April amounted to £20,800, and from January 1st to April 30th to £84,000. In the corresponding months of 1892 and 1891 the amounts were £82,800 and 88,000 respectively.

NEW SHANGHAI ELECTRIC COMPANY (LIMITED).—At the fifth ordinary general meeting of this Company, held at Shanghai, the Chairman (Mr. R. M. Campbell) said the working account showed they had made about Tls.500 more than they did last year, on a capital which had been increased by Tls.15,000, which had been borrowed at 7 and 8 per cent. This money was used specifically for the purpose of buying new incandescent plant of the latest and best type; it might have been better if they had been able to raise this additional amount. As things were at present in Shanghai, the Directors had made the best arrangements they could for carrying on the Company. The question of capital was really what bothered them most. As they went on developing and increasing their plant more capital was necessary, which they found it difficult to raise. The new machinery had only been erected during the last quarter of the year, but satisfactory increase had been the result of its erection. The Directors could at this moment employ immediately Tls.100,000 at a very profitable rate of interest, if they could only get it. During the time the Company had been working they had been fortunate in having a man like their superintendent to look after the Company's works, but he felt it to be a risky thing to have only one man at the works, and they had now got another man who was strongly recommended by their superintendent. Regarding arc lighting, that had not increased so much as they hoped it would have done. The Directors were authorised to pay a dividend at the rate of Tls.7 per share, and to deal with the balance as recommended in the report. Mr. R. M. Campbell was re-appointed a Director, and Mr. R. F. Eastlack auditor.

WELLINGTON (NEW ZEALAND).—The local gas company have resolved to amend their Memorandum of Association to enable them to deal with the subject of electrical supply,

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended May 5, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,849.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED.)—The receipts for the two weeks ended April 30th were £3,624, as compared with £2,656 for the corresponding period of last year.

WOODHOUSE AND RAWSON UNITED (LIMITED).—The following circular has been issued by Mr. F. D. Leslie (Receiver and manager) to the holders of First Mortgage Debentures and Debenture stock:—"In March last I was appointed by the Chancery Division of the High Court of Justice, Receiver and manager of this Company, on behalf of all the debenture and debenture stockholders, and since that time I have been endeavouring to arrive at the position and prospects of the undertaking, and to satisfy myself as to what would be the most advantageous course to pursue in the interests of the debenture holders and other secured creditors. I may say that I found the accounts in such a state that it was extremely difficult to arrive at either the amount due to the Company or its liabilities. I am now, I trust, succeeding in bringing the accounts into a satisfactory shape. There are so many branches and agencies spread all over the world that it is almost an impossible task in something less than two months to get at the true position of the whole undertaking. I have, however, with the sanction of the Court, despatched an agent to Africa, who will investigate the position there and look after the assets to the extent of over £20,000, which the books of the Company show are at Johannesburg and the other South African agencies. I have taken steps to preserve the assets in Sydney, and to settle the difficulties with the Barcelona and Milan agencies. I have closed down the Bristol branch and Hamburg agency, and am gradually doing likewise with the Cadby Hall works. I have reduced the expenses at head office on account on salaries, wages and rent at the rate of over £4,000 per annum. I have obtained leave to collect the debts due to the Company on behalf of and for the benefit of all the debenture and debenture stockholders, and to deal with the outstanding calls in the same way, except so far as they are specifically pledged as security for previous advances, and I have generally, so far as I have been able, done all that I can to keep the business alive and preserve the estate for the benefit of those who are entitled to it. It is very difficult to estimate what the various classes of debenture holders may reasonably expect from a realisation of the estate, because so much depends upon the way in which it is realised. Speaking with considerable doubt, I am inclined to think that the first mortgage debenture holders and the secured debenture stockholders (issued in December, 1892) may expect to be paid in full, but as to the debenture stockholders (5½ per cent.), I have very little doubt that unless some reconstruction scheme is proposed and carried through they will be considerable sufferers by the unfortunate stoppage of the Company. As to the feasibility of reconstruction and the proposals which are, I am told, about to be made, it is quite impossible for me to speak until some scheme in a concrete form is

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offered for the approval of the various classes of creditors. As soon as this is done (if at all) I shall consider it my duty to study the same, and to advise to the best of my ability the debenture stockholders whose collective interests I now represent. I shal at all times be anxious and ready to give every debenture and debenture stockholder all the information in power."

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The receipts the week ended May 5th were £2,847.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price. May 3.		Price Wednesday, May 10.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May	
								£ s. d.		Highest	Lowest
			TELEGRAPHS								
£1,247,720	Stock	12 6	Anglo-American	53	54	51½	52½	5 4 9	Jan., Apr., July, Oct.	52⅞	..
£2,876,140	Stock	25/0	Do. Preferred	94	95	93	94	5 17 0	,, ,,	94⅜	93⅝
£2,876,140	Stock	5/0	Do. Deferred	13	13½	12½	13	..	,, ,,	13⅛	12⅝
£250,000	100	4¾	African Direct, Telegraph 4% Debentures	101	104	101	104	3 16 11	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11⅜	12½	11⅜	12½	5 6 1	Mar., June, Oct., Dec.	12⅛	11⅞
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	106	110	107	111	4 10 1	June and December	..	..
$7,716,000	$100	$1½	Commercial Cable Capital Stock	140	150	140	150	4 13 4	April and October	..	..
16,000	10	8/0	Cuba Submarine	11½	12½	11½	12½	6 8 0	February and August	..	..
6,000	10	10%	Do. Preference 10%	18½	19½	18½	19½	5 2 7	,, ,,	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½	3½	2½	3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	,, ,,	..	..
60,710	20	3/6	Direct United States	11⅞	12	11⅞	12	5 13 8	Jan., Apr., July, Oct	12	..
400,000	10	2/6	Eastern	15½	15½	15½	15⅝	4 2 6	,, ,,	15⅝	15½
70,000	10	6%	Do. 6 per Cent. Preference	16½	17	16½	17	3 10 7	,, ,,	..	..
£1,294,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock.. xd	112	115	113	116	3 9 0	May and November	115	113
£105,900	100	5%	Do. 5 per Cent. Debentures 1899	107	110	108	111	4 10 1	February & August	109	..
250,000	10	6/6	Eastern Extension xd and Bonus	15½	15⅝	15⅝	16	4 7 6	Jan., Apr., July, Oct.	15⅞	15½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	113	116	114	117	3 8 5	February & August	114	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	104	107	104	107	4 13 6	January and July	105	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103	106	103	106	4 14 4	,, ,,	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101	104	101	104	3 16 11	February & August	102⅞	..
180,227	10	2/3	Globe Telegraph and Trust	9⅜	10	9⅜	10⅛	4 8 11	Jan., Apr., July, Oct	10	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	15⅝	15⅞	15⅝	16	3 15 0	,, ,,	15⅞	15⅝
150,000	10	7/2	Great Northern xd	19	19½	19	19½	4 7 2	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	106	..
17,000	25	12/6	Indo-European	43	46	43	46	5 8 8	May and November	44	..
38,348	10	4/0	London Platino-Brazilian	4	6	4	6	6 13 4	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
10,802	8	4/0	Reuter's	7	8	7	8	..	April and October	..	..
3,381	£100 Cert.	30 0	Submarine Cables Trust 6%	120	125	121	126	4 15 3	,, ,,	..	..
15,609	10	5/0	West African Telegraph	5½	6½	5½	6½	7 13 10	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100	103	100	103	4 17 1	March & September	102	100
30,000	10	2/0	West Coast of America	2	3	2	3	..	January and July	2⅞	..
£150,000	100	8%	Do. Debentures 8% 1902	98	102	102	106	7 10 11	June and December	102½	102
88,321	10	6d.	West India and Panama	1½	1⅞	1⅜	1⅝	..	,, ,,	1⅝	..
34,568	10	6%	Do. 6 per Cent. 1st Preference	11½	12	11½	12	5 0 0	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9½	10½	9½	10½	5 14 3	,, ,,	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	108	111	108	111	4 10 1	June and December	110	109
34,242	£5	3/0	Western and Brazilian	7⅞	8½	7⅞	8½	5 9 1	May and November	8	..
33,129	7½	3/0	Do 5 per Cent. Cumulative Preferred	6	6⅝	6	6⅝	5 15 7	,, ,,	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1⅞	2¼	1⅞	2¼	..	,, ,,	1¾	..
£129,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106	109	107	10	5 9 1	February & August	..	..
£237,200	100	6%	Do 6 per Cent. Mort. Debs., Series "B" 1910	106	109	106	109	5 10 1	,, ,,	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage xd	120	125	120	125	5 12 0	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	101	104	101	104	5 15 5	March & September	103	..
			TELEPHONES.								
40,000	£5	10/0	Chili Telephone (fully paid)	3	4	3	4	..	..	..	..
22,000	£1/0	1½d.	Consolidated Telephone Const. & Maintenance	1/16	1/8	1/16	1/8	..	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	⅜	½	⅜	½	7 18 2	Yearly	..	..
454,747	5	2/6	National	5½	5⅝	5⅝	5⅝	5 11 7	June and December	5⅝	5½
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15	15½	15	15½	3 17 6	,, ,,	15⅛	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14½	15½	14½	15	4 0 0	,, ,,	14½	..
90,950	5	6¾d.	Do. 5% Non-Cumulative 3rd Pref. (£3 paid)	5½	5⅞	5⅝	5¾	..	..	5¾	..
726 477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	113	116	113	116	3 17 7	January and July	115½	114
48,000	£10	..	New Telephone, Limited (£4 paid)	..	..	..	..	..	..	..	..
58,000	5	1/0	United River Plate	2	3	2	3	..	January and July	..	..
	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	,, ,,	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (fully paid)	12½	12¾	12½	12¾	..	..	12⅝	12½
20,000	£10	..	Do. 6 per Cent. Preference (£4 paid)	10½	11	10½	11	..	..	11	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	..	..	5	5¼	..	..	..	..
£47,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	..	..	..
8,332	£5	..	House to House Electric	..	..	1⅝	2⅛	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully pd.)	..	..	5⅝	5⅞	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	6	6⅛	..	January and July	..	..
30,000	£5	3/4 92	Liverpool Electric Supply (£3 10s. paid)	4½	4⅝	4½	4⅝	..	..	..	..
10,000	£5	5/0 '92	Do. (fully paid)	6	6½	6	6¼	..	..	..	..
111,000	5	..	London Electric Supply	..	..	..	..	..	..	..	..
43,900	£10	4/0	Metropolitan Electric Supply (fully paid) xd	6½	6¾	6½	6¾	2 19 3		6¹¹/₁₆	6⅝
£50,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, & £40)	102	105	101	104	4 16 2	June and December	103½	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	5	6	5	6	..	..	..	..
18,680	£5	9½%	St. James' and Pall Mall	7⅞	8½	7⅞	8¼	..	..	..	..
7,900	£5	7%	Do. 7% Preference	8	8½	8	8½	4 2 4	..	8⅛	..
42,853	5	2/0	Westminster Electric Supply (fully paid)	5½	6	5½	6	2 18 4	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/6	Brush Electrical Engineering	3½	3⅝	3½	3⅝	..	..	3⅝	3½
69,996	2	6%	Do. 6 per Cent. Preference	2½	2⅝	2½	2⅝	4 6 0	..	..	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	109	111	109	111	4 3 4	..	111	110½
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼	5⅜	5¼	5⅜	6 1 9	January and July	..	..
12,139	5	..	Edison and Swan United	..	..	..	..	..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..	..	1¾	2⅛	..	..	..	..
45,000	10	12/0	Electric Construction	2½	3	2½	3	..	..	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	⅞	⅞	⅞	⅞	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1	2	1	2	..	..	..	..
50,000	10	15/0	India Rubber, Gutta Percha & c., Works	22½	23½	23	24	5 4 2	February & August	23⅜	23⅛
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	102⅝	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½	3½	2½	3½	..	..	..	..
11,334	£10	8/0	Do. Preference	..	..	..	..	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	5/0	6/0	5/0	6/0	..	..	..	..
78,949	5	4/2½	Swan United (£3. 10s. paid)	3	3½	3	3¼	10 0 0	May and November	3⅛	3⅛
37,350	12	24/0	Telegraph Construction and Maintenance	29	31	30	32	5 12 5	March and July	31¼	29½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	102	105	4 15 3	January and July	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	..	..	..	..	..	..	..	..
..	£5	..	Do. Preference (fully paid)	..	..	..	..	..	..	..	..
			RAILWAYS AND TRAMWAYS.								
63,000	£10	..	City and South London Railway	..	..	..	..	..	..	..	..
600,000	Stock	2%	Do. Stock	37	39	37	39	2 17 8	May and November	37	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 783.—Vol. XXXI. FRIDAY, MAY 19, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

In his well-earned promotion from the secretaryship of the Railway Department of the Board of Trade to the Permanent Secretaryship of that ever-growing Government office, Sir Courtenay Boyle will, we feel sure, carry with him the best wishes of the electrical industry. The Act of 1882 was nothing more than a legislative skeleton, the vital details of which had to be filled in by the Board of Trade in addition to carrying out the work of administration. To meet the wishes of Parliament and safeguard the public without at the same time altogether stifling a struggling industry, was a hard problem even for permanent government officials, and the measure of success which has attended the efforts of the Board of Trade is largely due to the tact and "plain good intention" of the new Permanent Secretary.

It is to be hoped that with a set of new engines and dynamos, an elaborate condensing plant, a second line of trunk mains, and a fresh lot of house transformers, the London Electric Supply Corporation has, at last, passed the "experimental stage;" that its capital expenditure, now amounting to £821,000, has terminated; and that a profit, if not a dividend, may be earned by December next. The total paid-up capital of the Company is £836,000 in round figures: to pay, say, 5 per cent. on this would require £42,000. The total receipts last year were £24,282, and the total expenses £28,196, so that the Directors and engineers have certainly need of all their patience and ingenuity. There is good reason for attributing the position of this Corporation to sheer bad luck rather than to faulty design. The load was transferred to the Deptford station in October, 1890, and the very next month the fire at the Grosvenor Gallery sub-station compelled the shutting down of the supply for three months, thus losing the winter's work. Starting again with 9,000 lamps in February, 1891, they quickly picked up to 23,000 in May, and by the end of the year had reached 36,000, or about 2,000 less than at the date of the Grosvenor Gallery fire. The next accident, the burning of the mains at Spa-road, shook the faith of their customers, and only 1,000 lamps or so were added during 1892. While the connections during the present year seem to be at the rate of about 22,000 per annum and have reached 57,000, the cutting of prices by the competing companies adds another burden to the difficulties against which this Corporation has been fighting. What mercy they would have shown their rivals had all gone well, and had the huge plant at Deptford been fairly loaded, we need not venture to guess.

Those interested in the latest birth of time, the alternate-current transformer sub-station system of distribution, will do well to take note of the case "Lindsay v. Cowper," which we report in our "Legal Intelligence" this week. If the ticking of a meter and the "hum" of transformers twenty feet below the street are to constitute an actionable nuisance, the alternate current men are evidently not out of the wood yet.

The manifesto, if we may so call it, which we publish this week over the names of Messrs. Crompton, Garcke, and Sydney Morse is a distinct sign that the National Telephone Company's proceedings in regard to electric traction are at last to be placed in their proper light, and that there need be no fear lest judgment should go against the claims of electric traction by default at the forthcoming Parliamentary inquiry. The last paragraph embodies a statement of the case, which has been made over and over again in these columns, namely, that it is a question as to whether the public are to be permitted to enjoy a cheap and efficient mode of traction or are to allow single-wire telephony to be perpetuated. The contention of the National Company, that the insulation of tram-wires is as easy, as cheap, and as imperatively necessary as that of electric light conductors, is ingenious, and likely to have much weight with a non-technical committee. As an answer, it will, however, only be necessary to point to the Folkestone case, where the Company declined to carry out this cheap, easy, and necessary job at its own expense, preferring to pay the promoters' costs, which were decidedly in excess of the Company's estimate for insulating the tram return.

In connection with the controversy which has recently taken place in our columns, and elsewhere, as to the relative claims of the various inventors of non-synchronous alternate-current motors, we have just received two letters which involve two fresh claims of priority. One of these is advanced by the well-known electrician, Herr Jehl, of Brünn, who reminds us of an article appearing in *The Electrician* for October 28, 1887, in which he describes a method of starting motors by producing a rotating magnetic field in a manner very similar to that recently given in the *Elektrotechnische Zeitschrift* in an article written by Herr Arnold of the Oerlikon Works. On referring to this six-year-old article, we find the fact to be as

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stated by Herr JEHL, but the result is only achieved by means of a complicated commutator and numerous brushes. Moreover, the chief object the inventor had in view was the transformation of direct currents. After all, the production of a rotatory magnetic field is not in any way new, although the recently-acquired habit of referring to such a field by the foreign name of "drehfeld," has made it appear so. Long before 1887, Profs. AYRTON and PERRY devised a motor in which the power applied to the moving part was maintained by means of a rotating field. In this motor the fixed coils were wound continuously in a Gramme ring, and were connected with a commutator in the ordinary manner. A steady current was passed through the ring by means of two brushes pressing on the commutator segments, and revolving over its surface. Some of the recently-devised methods of getting rotating fields involve this plan.

THE other claimant we alluded to is Dr. HANS BEHN-ESCHENBURG, who states that the motor recently described by Mr. BROWN is exactly the same in principle as several motors which have been for some time in use in the Oerlikon Works. After inventing these motors, and, apparently, while preparing a Paper dealing with their theory and historical origin, the learned Doctor seems to have made the unexpected discovery that much of the merit of priority is due to ELIHU THOMSON and TESLA. The disadvantages of the Oerlikon motors are stated to be the excessive current at starting or on light loads and the small range of speed and torque available. With the view of getting rid of these defects Dr. ESCHENBURG has introduced some interesting novelties in the construction of these motors. Briefly stated, the moving and stationary parts are each magnetised by a set of coils joined together in series like a Gramme ring, and connected up in the usual way to the bars of a commutator. The moving part receives current from two fixed brushes rubbing on the commutator. The commutator connected with the fixed coils is also provided with two brushes, whose position is adjustable, connected to a resistance the magnitude of which can be varied. By adjusting the position of the brushes and the magnitude of the subsidiary resistance, it is stated that it is possible to start the motor on full load with a comparatively small current, and also that the speed and torque are adjustable without more sparking occurring at the brushes than is the case with a direct-current dynamo. No data are yet available in confirmation of these statements, nor is any indication given of the magnitude of the power wasted in the subsidiary resistance, or of the size of the motor compared with a direct-current motor of the same output.

THE article on the accuracy of copper voltameters, which we publish this week, calls attention to a matter of no small commercial importance which does not appear to have received the attention it deserves. It has long been well-known that the theoretical quantity of copper is not deposited on electrolysis, and that the weight of metal yielded varies in an irregular fashion both with the current density and with the amount of acid in the solution; but no systematic attempt to explain the discrepancies observed, and to suggest a remedy, appears to have been made before, although those engaged in the recovery of copper by electrolysis were fully aware that they were not obtaining the theoretical yield. Dr. OETTEL has shown the mode in which the difficulties connected with the electro-deposition of copper may be overcome, and when it is taken into consideration that he finds this is effected by the addition of a reducing agent, there can be little doubt that the loss is due to the greater or less quantity of persulphuric acid and persulphate of copper formed in the electrolyte according to the conditions of working. Those who have had experience of working with Daniell's cells are aware that copper is deposited on any speck of carbon which may exist in the porous pots; and, further, that this deposition takes place when the cells are at *rest*. Dr. MARSHALL showed in 1891 (*Chem. Soc. Jour.*, 1891, p. 784) that copper persulphate exists, and that it is a very unstable body, and it appears not improbable that the deposition of copper which takes place during rest after electrolysis is due to the decomposition of this body.

"COOKING by electricity" has been gradually developed after persevering experiment, and has now become well established. Seldom has a useful branch of trade been started under such ridicule. Not the necessary kitchen boiler but the frivolous drawing-room tea-kettle, not the conservatory stove but the perhaps more frivolous curling-tongs, have received attention from clever electricians. There is a good deal more in the design of these appliances than at first sight appears. The selection of the best kind of enamel and a suitable alloy from which to draw the wire, have been carefully studied, and no wonder they are kept secret. Unlike electric lighting, for which wretched wooden lampholders, bad wire, and cheap switches were at first used, while the supply of current was costly, the difficulty in electric cooking has been the high price of the utensils, though the cost of current is small enough. The result, however, is as it was with electric lighting, that electric cooking has been an expensive luxury. With the exception of some figures given by Prof. AYRTON at the Royal Institution in a lecture which, as far as we are aware, has never been printed, no authoritative statement has been published about the cost of current. Mr. DOWSING gives some interesting information in a letter which will be found in our Correspondence columns, and undoubtedly establishes the small cost, not as compared with gas or spirits, but the small absolute cost of electric supply for these purposes. We hope that the price of the apparatus will soon be reduced.

IT has been assumed by theorists who would, probably, be quite incompetent to design an electric kettle or grill that the efficiency of such apparatus is 100 per cent. We have ourselves admitted in some calculations on this subject (*The Electrician*, Vol. XXVIII., p. 478) that the whole of the energy is turned into heat, but it does not follow that the apparatus utilises the whole of it. Careful lagging with asbestos, and the production of the heat at the exact point at which it is required, are necessary, and a reduction in the thermal capacity of the hot plate seems advisable, for though

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this acts as a kind of fly-wheel, checking the sudden rise of temperature of the resistance wire and afterwards giving out a steady delivery of heat, it is evident from Mr. DOWSING'S figures that the cost of warming up greatly exceeds the expenditure during the process of cooking.

THE breakfast-table egg-boiler is all very well, but unless a chemist's "stink chamber," with its usual powerful ventilating appliances, is provided on the side-board, the grill and frying-pan must be kept in the kitchen, in spite of the ease with which they can be connected to any lampholder. We would, however, suggest that, now we have no dining-room fires, a bottle-warmer to take the chill off the claret would be easy to make and convenient to use. The electric cigar-lighter is, at present, an absurdly clumsy arrangement, with a big handle containing a mercury switch, a box against the wall with a resistance, or an unusually ugly bracket and lamp. Could not a little affair be made about the size of a cigar-cutter, or, perhaps, combined with one, and arranged to cut in in series with the lamps used for lighting the table?

Electric Traction in Toronto.—Over seventy miles of additional electric tram lines are to be laid during the coming summer.

Académie des Sciences.—Prof. Rowland has been elected Correspondent pour la Section de Physique in place of the late M. Soret.

"Practical Physics."—A fourth edition of Glazebrook and Shaw's "Practical Physics" has been issued by Messrs. Longmans, Green, and Co.

Electric Launches.—Four electric launches are to be put on a large lake near Berlin by the Allgemeine Elektrizitäts Gesellschaft, the largest accommodating sixty persons.

Nottingham.—Mr. F. H. Tulloch, an inspector of the Local Government Board, held a local inquiry on Thursday last week with regard to the application of the Corporation for sanction to borrow £45,000 for the purpose of lighting the town by electricity.

"Popular Lectures and Addresses."—A French translation of Lord Kelvin's "Popular Lectures and Addresses" has been published by MM. Gauthier-Villars et Fils. The translator is M. Lugol, who has added notes of his own. M. Brillouin has contributed translations of extracts from recent papers by Lord Kelvin.

The Design and Construction of Dynamo Machines and Transformers.—On Tuesday, May 30th, Mr. Swinburne will deliver the first of a series of lectures on "The Design and Construction of Dynamo Machines and Transformers" to the students of the Electrical Standardising, Testing, and Training Institution.

Royal Society.—A Paper by Dr. Beevor and Prof. Horsley, entitled "A Further Minute Analysis by Electric Stimulation of the so-called Motor Region of the Cortex Cerebri in the Monkey," was down for reading yesterday before the Royal Society.—The late Lord Derby has bequeathed a sum of £2,000 to the Royal Society.

Cable Interruptions and Repairs:—

	Interrupted.	Repaired.
Gibraltar-Tangier	April 29th.	May 16th.
Para-Maranham	March 20th.	—
Paramaribo-Cayenne	April 15th.	—
Santiago de Cuba-Mole St. Nicholas.	April 20th.	—
Asab-Massowah	May 15th.	—

Thunderstorms.—During the week the Thames Valley, the Midlands, and Devonshire have been visited by more or less severe thunderstorms. At Tiverton, The Lodge, the residence of Major Fletcher, was damaged by lightning, which struck a large chimney, passed through the slate roof into a dressing-room, here fused the wire of a picture, followed the course of a wire bell-rope, and entered the wall. From the dressing-room the discharge travelled to the pantry, fusing a gas-pipe, and knocking off and blackening the mortar.

Electric Traction Patents in America.—The two patents recently granted to the assigns of the late Mr. Chas. J. Van Depoele, cover the essential features of the trolley. The patent is assigned to the Thomson-Houston Company. The claims allowed cover, first, the underneath contact made either by a rolling wheel or a sliding spoon contact piece; secondly, the converse of these two cases; and, thirdly, the reversibility of the trolley pole on top of the car, enabling the contact to be made on either side of the trolley, as the case may be.

Interurban Telephony.—Bregenz, on the Lake of Constance, and Feldkirch, on the Swiss frontier, are to be telephonically connected. Extensions of the line will run from Bregenz to St. Gallen, in Switzerland, on the one hand, and to Lindau, in Bavaria, on the other. On the 20th ult. the Vienna-Prague telephone trunk line was opened. The opening of this line places Vienna subscribers in connection with all the Bohemian towns, some twenty in number, connected with Prague. The charge for three minutes' conversation is 1fl. 50kr. (3s.)

"Stabilit."—This is the name given by the Allgemeine Elektricitäts Gesellschaft of Berlin to a new insulating compound, the ingredients of which are, of course, a secret. "Stabilit" has a specific gravity of 1·6, and a specific insulation resistance of 10,000 megohms per cubic centimetre. It is stated to be able to resist acids, damp, high temperatures and high electrical pressures. Its inventors have for some time past used it for armatures, commutators and switch-boards. The substance takes a high polish, and lends itself to all manner of working.

The Westinghouse and General Electric Companies.—The American daily papers to hand contain most sensational accounts of an impending legal fight between the Westinghouse Electric Company and the General Electric Company. It is alleged that prices, specifications and designs have been sold by Westinghouse *employés* to the General Electric Company. A superintendent of the latter Company has already been arrested, as well as several Westinghouse *employés*, and it is stated that warrants are out for the arrest of high officials in the service of the General Electric Company.

The Post Office and Railway Messages.—On the consideration of the London and North-Western Railway Bill, as amended, the following clause has been, on the motion of Mr. A. Morley, added to the Bill:—Nothing in this Act shall be deemed to impose upon the Postmaster-General the obligation of transmitting, under the provisions of "The Telegraph Act, 1868," or any agreement between the Postmaster-General and the Company made in pursuance thereof, any larger number of telegraphic messages of the Company free of charge than he would have been bound to transmit had this Act not become law.

Yarmouth.—A petition, signed by 200 tradesmen and others, was read at the last meeting of the Town Council, asking the Mayor, on behalf of the inhabitants generally, to cause a poll to be taken to ascertain whether it was really the wish of the ratepayers that an electric lighting scheme should be undertaken by the Corporation. The Clerk said the Mayor had no power to order a poll to be taken. As application had been made to the Local Government Board to sanction the borrowing of £15,000 for electric lighting, a public inquiry would be held, of which public notice would be given. Any persons who were opposed to the scheme could attend and state their views,

St. Pancras Street Lighting.—At the meeting of the Vestry, on Wednesday of last week, attention was called to the inconvenience occasioned by the failure in the electric light on the previous Monday night. The arc lamps in Euston-road went out, and the thoroughfare was in darkness for an hour and a-half. Mr. Gibb said, though the failure was a small thing in itself, yet it was most important from the point of view of the ratepayers. He did not think the failure had anything to do with the coals, but was the fault of the stokers in charge. Mr.

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Edward Cox said that this was the second time that a failure of the kind had happened, and on both occasions it had occurred when the same men were on duty. A full inquiry would be made by the Committee. Mr. McGregor said the supply of current was most irregular. A full inquiry was promised.

The Edison Lamp Patent in France.—The Neuvième Chambre du Tribunal de la Seine has given judgment in an action for infringement brought against M. Khotinsky's French concessionnaire by the Société Générale des Lampes Incandescentes, owning the Edison patents. The Court decided :—(1) That the Edison patents, upon which the plaintiffs rely, are themselves null and void, and cannot, owing to the anticipations investigated by the experts, give the Société Générale des Lampes Incandescentes the right to claim an exclusive property in an electric lamp consisting fundamentally of a carbon filament of high resistance enclosed in an exhausted bulb and connected to platinum conductors traversing the glass of the bulb. (2) That the Khotinsky filament made from a cellulose, amorphous, colloidal paste has, moreover, nothing in common with the Edison filaments made from fibres or fibrous substances. On another issue the Court decided that it was an infringement to make use in new lamps of patented sockets taken from old lamps.

Obituary.—We regret to announce that on May 1st, at Salina Cruz, Mexico, Mr. James Ford Lumsden, son of the Superintendent of the Submarine Department of the General Post Office, was drowned by the upsetting of a boat while landing the shore end of a cable from the ss. "Silvertown." Mr. Lumsden was in his 24th year. He had served on both the engineering and electrical staff of the Silvertown Company, and showed great promise.——We record with regret the death of Mr. E. J. Burt, of fever, on Sunday last, at Sao Thomé, West Coast of Africa, aged 41. The deceased, who was the Superintendent of Sao Thomé Station and latterly acted as Superintendent of the whole of the West African Company's system, joined that Company's service in October, 1885. He had previously seen some thirteen years' foreign service in Central and South America. He was respected alike for his administrative ability and for his natural urbanity, and his premature decease has deprived the Company of an excellent officer. His loss will be keenly felt by a large circle of friends connected with telegraphy in all parts of the world.

Copper.—It would appear that Tasmania may yet be an important producer of copper. Dr. E. D. Peters in his report on the Mount Lyell Company, says that there are several bodies of barren pyrites in the world as large or larger than this one, but its only competitor among the valuable pyrites bodies of the world is the Rio Tinto mine, in Spain, which is three or four times as large as the Mount Lyell mine, but only one-third as rich. He also says that, after making deductions for poor parts of the ore body, there are several million tons of good ore available above the present drainage level of the valley, which can be extracted by simple quarrying and without cost of pumping or hoisting.—Further particulars have been received from the officials of the South-west Africa Company in Damaraland with regard to the recent discovery of copper north of Otavi. They describe it as the finest mineral outcrop they have ever seen.—The copper statistics show an excess of consumption over supply, with the result that on May 15th the visible stock had fallen to 50,289 tons, compared with 52,094 tons at the end of April, and is now smaller than at any time since the operations of the French syndicate.

Electrical Bills in Parliament.—The Unopposed Bill Committee of the House of Commons have passed the Bill confirming Electric Lighting Provisional Orders granted by the Board of Trade to the Vestry of Hammersmith, and the District Boards for Hackney and Poplar. The examiners of the House of Commons have ordered to be reported for second reading the Bill confirming the Electric Lighting Provisional Orders granted to the Bridgend Local Board and the Taunton Town Council. On Monday the Bill for amending the City of London Electric Lighting Bill was read a first time, and referred to the examiners of petitions for private Bills. On Tuesday, the Barry Railway Bill was read a third time. The Electric Lighting Provisional Order (No. 1) Bill was referred to a Select Committee of the House of Commons, of which Mr. A. De Tatton Egerton was chairman, and which met on Monday. The Bill was opposed by the Corporation of Glasgow. In the House of Lords on Monday the Electric Lighting Provisional Orders (No. 2) Bill was read a third time and passed. On Friday of last week the Royal Assent was given to the Kensington and Knightsbridge Electric Lighting Company's Bill ; and the Hampstead, St. Pancras and Charing Cross Railway Bill, the Brighton and Rottingdean Seashore Electric Railway Bill, were read a second time.

M. Dolivo-Dobrowolsky and the Brown Motor.—The *Elektrotechnische Zeitschrift* for March 31st contains a lively impeachment of Mr. Brown and his motor, from the pen of M. Dobrowolsky. The latter asserts that he built a practical three-phase motor at the works of the Allgemeine Elektrizitäts-Gesellschaft in 1889, and that some data were sent to the Oerlikon Company, and the 3-4 H.P. motor was shown to Messrs. Huber and Brown in 1890, who thought so well of it that they entered into an agreement to manufacture under licence, and to work on improvements in concert with the Gesellschaft. Before this, no alternate-current motor had worked at Oerlikon. This, says the author, disposes of Brown's claims to priority. Under the agreement, M. Dobrowolsky gave, both by letter and word of mouth, details of the machines to Mr. Brown, and he gives long quotations from his letters. The armature of Brown's motor, says the author, is entirely taken from his; and he shows that his armature has been improved so that it runs as much as 50 ∿, whereas he quotes Mr. Swinburne to show that Brown's will not run over 25 ∿. Winding through holes in the iron was tried by M. Dobrowolsky in the machine shown to Mr. Brown, and has been done away with by using notched armatures; and those constructed by Mr. Brown under M. Dobrowolsky's instructions have been much improved by his successor at Oerlikon. The connection of Mr. Brown with the development of the alternate-current motor is, says the author ironically, perfectly clear. After criticising the details of the "new" motor, the author gives some details of the three-phase motors of the Allgemeine Elektrizitäts Gesellschaft, running at 50 ∿, and challenges Mr. Brown to produce similar figures for his motors, and to run his motor against that of M. Dobrowolsky.

The Hummel-Schuckert Meter.—In a recent number of *L'Electricien*, M. E. Meylan describes the Hummel-Schuckert meter, which has come into tolerably wide use in Germany and Switzerland, and also gives the results of some tests. This meter may be briefly designated as a German variety of the Elihu Thomson motor meter. The field-magnets are excited by the series coil. The armature is in shunt, and in series with it there are the coil of the retarding electromagnet and the coil acting on the armature and intended to compensate for friction. The armature is merely a spheroidal bundle of wires. The damping device is extremely light. The commutator of the motor is formed by seven silver segments, the brushes each consisting of a strip of silver bent into a U, the edges bearing on the commutator. According to M. Meylan, the performance of the Hummel meter compares badly with that of Elihu Thomson. A 10-ampere meter was taken, and the volts were kept 98·5, whilst the current was varied from 0·2 to 8·15 amperes, then the volts were kept at 100 and the current varied from 0·4 to 13·6 amperes; finally the current was kept at 2 amperes, and the volts varied from 111 to 95. The results showed that the compensating coil was too powerful, and the core of the retarding electromagnet insufficiently saturated. M. Meylan points out that the great thing in these motor meters is to obtain relatively powerful torques in order to reduce the influence of friction to a negligible quantity. The torque of the 10-ampere Hummel meter at full load is 10·4 gramme-centimetres, that of an Elihu Thomson 15-ampere meter being 20 gramme-centimetres, the moving parts of the latter being, however, somewhat heavier. M. Meylan then shows that the horizontal component of the earth's magnetism, not to mention externally-placed magnets, may have a marked effect on the readings, owing to the comparatively weak field of 120 C.G.S. units at full load. The horizontal component of the earth equals 0·2, so that it may cause a variation of 0·4/120, or 0 3 per cent. at full load, or 3 per cent. at one-tenth load.

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THE ACCURACY OF THE COPPER VOLTAMETER.

BY BERTRAM BLOUNT, F.I.C., F.C.S.

The fact upon which the use of an ordinary voltameter is based, namely, that a given current performs a definite and constant amount of chemical work, is not to be gainsaid; but the common deduction, therefrom, that if two strips of copper are immersed in a solution of copper sulphate and the gain of the cathode determined after the passage of a current an accurate measure of that current is obtained, cannot be accepted without reservation. At a date not very distant, a nice, neat, simple equation was thought to express with accuracy any typical straightforward reaction, and anything simpler or more straightforward than the electrolytic decomposition of copper sulphate it was difficult to conceive. But chemists, who are a prying, unsatisfied race, have disturbed this comfortable belief, thereby greatly distressing many worthy makers of books and the honourable company of examiners and examinees, and have searched for, and in too many instances found, secondary reactions accompanying those which are more obvious, with the result that many a symmetrical expression has become sadly lopsided. It is in some sense consoling that the destruction of a favourite superstition has, in this case, been attended with practical advantage, and though the decomposition of copper sulphate may have been found to be irregular to the verge of impropriety, a knowledge of its vagaries may be applied to the attainment of greater accuracy in results arrived at by its means. The subject has attracted some attention on the Continent, and a series of experiments by Dr. Oettel has recently been published in the *Chemiker Zeitung*, from which a good deal of interesting information may be gleaned.

In the first place, if the decomposition of copper sulphate were perfectly regular it would obviously be a matter of indifference whether copper or platinum electrodes were used, for the only immediate effect of the substitution of the latter for the former would be an extra drop of voltage due to the fact that copper was not being merely transferred from the anode to the cathode, but that it was being actually reduced from its sulphate. In an apparatus containing platinum electrodes, however, and with a current density of 0·13 ampere per square decimetre (about 0·0084 amperes per square inch) of the cathode surface, the amount of copper deposited ranged from 73·9 to 89·2 per cent. of that thrown down in a voltameter with copper electrodes included in the same circuit. No evolution of hydrogen appeared to take place at the cathode, so that it was not at first clear what work other than the deposition of copper had been done by the current. As both the copper sulphate and sulphuric acid were chemically pure, no explanation was forthcoming based upon any irregularity in the composition of the electrolyte, and the cause of the low results was sought in some change at the anode, by which less than the calculated amount of oxygen appeared there as gas. Only three bodies seemed likely to be formed, namely, ozone, hydrogen peroxide and persulphuric acid. The first was put out of court by the fact that the oxygen was free from the very powerful and characteristic smell of its allotropic modification. Of the two remaining substances, persulphuric acid, HSO_4, is the more likely to have been produced, as recent researches have shown that this acid and its salts are quite readily prepared by means of electrolysis, but it is to be regretted that no attempt was made to settle the question in a satisfactory manner. The reactions of hydrogen peroxide with chromic acid and titanic acid should have sufficed to dispose of the doubt as to its presence, for those which were actually tried, such as the liberation of iodine from potassium iodide, are given by hydrogen peroxide as well as by persulphuric acid. One of Dr. Oettel's experiments, indeed, points plainly to the presence of hydrogen peroxide. He found that the liquid at the anode decolourised a solution of potassium permanganate, a reaction by which Dr. Marshall (*Chem. Soc. Jour.*, 1891, p. 774) distinguishes hydrogen peroxide from the persulphates. Whichever substance was formed, however, its effect was the same. After its formation at the anode, it diffused through the liquid to the cathode and there was reduced instead of copper, the net result being extra work in the cell, which finally appeared as heat. Persulphuric acid being still a comparative novelty, and being, moreover, by no means particularly stable, would certainly be overlooked by many, and it it is just as well to call attention to its existence and the ease with which it is formed when sulphuric acid or a sulphate is electrolysed.

The influence of current density is not easy to reduce to a definite rule, but it seems from such facts as have been collected, that the use of a small anode, as compared with the cathode, favours the formation of persulphuric acid, and therefore a loss of copper. This is quite in accord with the well-known effect of a small anode on the production of ozone by the electrolysis of dilute sulphuric acid, a wire being found preferable to a plate, and the mere end of a wire better still. Raising the content of acid in the electrolyte also decreases the amount of copper deposited, both from the enhanced production of peroxidised products at the anode, and also from the action of the acid on the copper at the cathode tending to redissolve it. The material of which the anode is made is not without influence on the results. Lead, when used instead of platinum, becomes coated with a film of lead peroxide and is then scarcely attacked, while the amount of copper deposited increases to 97-98 per cent. of that thrown down in a copper voltameter in the same circuit. This fact again goes to show that hydrogen peroxide is one, at least, of the products at the anode, for it is decomposed by lead peroxide, with the formation, in the presence of sulphuric acid, of lead sulphate and oxygen, and thus less loss from the reduction of a peroxodised body at the cathode takes place, while the formation of lead sulphate involves a slight increase in the voltage of the current passing through the cell, the energy requisite being furnished by the heat of formation of lead sulphate. A persulphate, on the other hand, although readily decomposed by treatment with a salt of lead on account of the unstable character of lead persulphate, does not react with lead peroxide in the same manner as does hydrogen peroxide. These considerations lend considerable weight to the belief that hydrogen peroxide, as well as persulphuric acid, is among the products at the anode, in which case the addition of a trace of manganese sulphate added to the electrolyte should have the same effect as the use of a lead anode, for the resulting manganese dioxide would also decompose hydrogen peroxide. The suppression of the peroxidised body at the anodecan be effected by other means than the use of a metallic peroxide at the anode. Thus, when formic acid, which is readily oxidisable, is added to the contents of the decomposing cell, the yield of copper rises to 98·7-99·6 per cent. of the theoretical amount. Alcohol is even more active, and the copper separated is as much as 99·5 to 99·9 per cent. of the ideal quantity. That the reaction takes place on the lines already indicated is proved by the formation of a considerable quantity of aldehyde, the lowest oxidation product of alcohol, at the anode. Aldehyde is not readily reduced to alcohol, so that no loss due to the reverse reaction takes place at the cathode. The energy evolved in the oxidation of the alcohol probably appears in the form of heat, there being no evidence that it contributes to the electrical energy of the system.

These observations rather cast doubt on the accuracy of the copper voltameter, in which both electrodes are of copper, at least when used with an acid electrolyte. This is a matter of practical importance, as the copper voltameter is constantly used in preference to the silver form of the instrument, not only because of the difference in the price of the two metals, but also on account of the compact condition in which the copper separates, while the silver, on the other hand, is loose and crystalline—a drawback in lengthy runs. The usual prescriptions for setting up a voltameter to give reliable results insist on the necessity of using a neutral solution of copper sulphate in spite of the high resistance thus caused, a resistance that is lowered one-half by the addition of a moderate quantity of sulphuric acid. The observation recorded above, that the addition of alcohol prevents the tendency to low results in a voltameter having an insoluble anode, suggests the possibility of avoiding the loss generally supposed to be incurred by the addition of acid, by the same means. The upshot of a long series of experiments by Dr. Oettel with varying current and current density may be stated as follows:—An acid solution of copper sulphate containing alcohol

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gives results which agree with those of a standard copper voltameter and of the silver voltameter. With a current density below 0·3 ampere per square decimetre (0·0193 amperes per square inch), the ordinary copper voltameter, working with a neutral solution of copper sulphate, gives false results, the weight being unduly increased by the presence of imperfectly reduced copper in the form of cuprous oxide in the deposit. This does not take place with an acid solution containing alcohol.

Finally, Dr. Oettel gives the proportions which he has found most effective for setting up a voltameter free from the objections that can be urged against the ordinary form. The electrolyte consists of a solution of 15 grms. of copper sulphate, 5 grms. of sulphuric acid, and 5 grms. of alcohol in 100 grms. of water. It can be used with a current density ranging from 0·06 to 1·5 ampere per square decimetre (0·0039 to 0·97 amperes per square inch) of cathode surface, and has a resistance half that of a corresponding instrument filled with neutral solution of copper sulphate.

In closing this appreciation of an admirable piece of work, I cannot refrain from recording a few suggestions to which it has given rise. In the first place, the study of the precise nature of the products at the anode would, in my opinion, lead to the detection of hydrogen peroxide as well as of persulphuric acid. Next, there is not only a probability of the presence of oxygen in the copper deposited by a current of low density, but also a prospect, in the reverse case, of the separation of hydrogen at the cathode and its occlusion by the copper. The tendency of copper to associate itself with hydrogen is well marked, even when reduced by dry methods, and the existence of hydrogen in metals obtained by the electrolysis of aqueous solutions of their salts, generally recognised. Finally, as the re-solution of copper from the cathode cannot be effected by the action of dilute sulphuric acid in the absence of oxygen, voltameters of precision should preferably be so arranged that the atmosphere above the electrolyte could be an inert gas like nitrogen. By paying regard to such precautions a substantial advance in accuracy would be gained.

ON THE PREVENTION AND CONTROL OF SPARKING; CONTINUOUS-CURRENT DYNAMOS WITHOUT WINDING ON THE FIELD-MAGNETS, AND CONSTANT-PRESSURE DYNAMOS WITHOUT SERIES WINDING.*

BY W. B. SAYERS.

The object of this Paper is chiefly to lay before the Institution certain means for bringing under independent control the commutation of ring and drum armatures for continuous currents. The limits dependent on considerations of sparking at the brushes being thereby done away with, a new field of design is opened up. Mr. Swinburne and Mr. Esson—the former in his Paper read before this Institution in 1890, and the latter in his Papers in 1890 and 1891—both give expressions for the maximum load which can be carried without sparking; these expressions are in terms of the ampere-turns upon the armature, the length of the air space, the angle subtended by the polar surfaces of the field magnets, and the forward induction. Thus, it is recognised that in ordinary ring and drum-armature machines the consideration of sparking fixes, or at least limits in one direction, some of the most important elements in the design of the machine, and is not separately controllable. A practical result from this is that the lightening of machines by putting the conductors in tunnels, reducing the air space to a mere clearance—which has been proposed from time to time, notably by Mr. Swinburne, and which is the condition in which minimum exciting force is required, and, consequently, the condition of minimum weight of magnets—has not been hitherto practicable. The conditions of sparkless collection, when no special means are employed for bringing about the reversal of the sections as they pass the diameter of commutation, are now well understood; but as I have found it somewhat difficult to describe the action of the devices which I wish more particularly to bring under consideration, I have prepared four diagrams which I think represent the action fairly well, and which will at least be useful as a stepping-stone towards that which I wish to describe later on.

* Paper read before the Institution of Electrical Engineers, May 11th.

In diagrams 1 and 8 I have ventured to distinguish the currents flowing from the two halves of the armatures by red and blue colouring* beside the wires in which they are flowing. This is merely to enable me to refer briefly to the two halves of the current, and to clearly distinguish them in the diagrams.

Diagrams 1 to 4 represent part of an ordinary ring-armature machine spread out flat. Suppose, as is the case usually, the brush makes contact over an angular breadth equal to that of one section of the commutator, or a little more; then the current reaches the brush alternately through one commutator bar, and through two. Figs. 1 and 3 represent diagramatically these two conditions. In Fig. 1 the commutator bar C is represented centrally under the

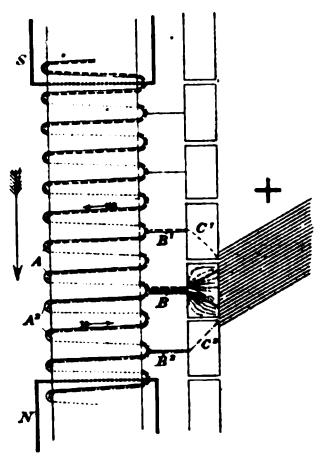

Fig. 1.

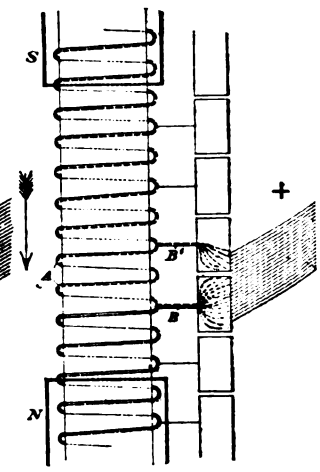

Fig 2.

brush. In this position the currents flowing from the two halves of the armature unite in the commutator connection B, and flow thence through the commutator bar to the brush. As the armature moves onward in the direction indicated by the arrow, the armature coil A is seen to be short-circuited under the brush. The current flowing in it at the moment when it becomes short-circuited would be counter clock-wise, looking from the lower end, but the coil, from its position, is beginning to cut lines of force in a sense tending to induce a clock-wise current. The counter clock-wise current,

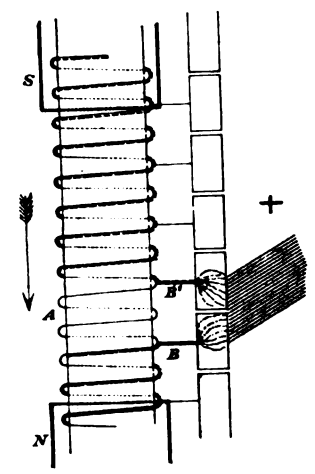

Fig. 3.

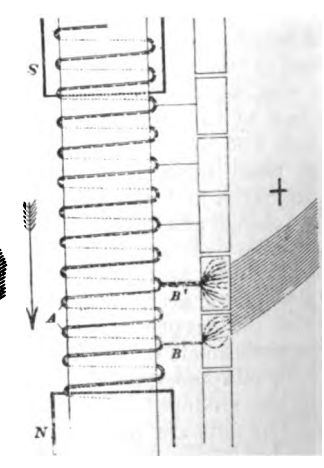

Fig. 4.

therefore, falls, and at the same time a current rises in B^1, such that the current in B, *plus* the current in A, equals at any moment the half-armature current. Fig. 2 represents the position when the red half is equally divided between B and B^1, B carrying in addition the whole of the blue half. The next stage is shown in Fig. 3, when the current in the armature coil A is passing through zero value; at this instant the blue half of current flows to the brush by B alone, and the red half by B^1 alone. A clock-wise current now commences to rise in A, the current in B falling correspondingly. Fig. 4 shows the position when the blue half is equally divided between B and B^1, while B^1 carries in addition the

* In the blocks — — — stands for red colouring, and —·—·— stands for blue colouring.

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whole of the red half. As the armature still moves on, the position shown in Fig. 1 is again reached, the current in A having risen, under the influence of the induction, to the value of half the armature current. At the instant when this is so, the current in B^2, Fig. 1 (which we now look upon as B moved through the angular distance of one section), is necessarily zero, and if the tip of the brush breaks connection with the commutator at this instant the break will be sparkless.

Several devices have from time to time been proposed for controlling sparking at the brushes of dynamo machine—notably the use of reversing pole-pieces. Mr. Hookham, of Birmingham, told me—I think in 1889—that he had succeeded in obviating the necessity of moving the brushes for varying loads by their means. Mr. Swinburne has also advocated the use of reversing pole-pieces; and Mr. Edison has from time to time since 1883 patented various arrangements with the object of introducing a counter electromotive force into the short-circuited coil, with the object of avoiding sparking and the necessity for moving the brushes with varying loads.

Still, there would appear to be in the minds of some a vague idea that sparking is due generally to an abnormal current being generated in the coil which is short-circuited under the brush. That is far from being true as a general rule, as appears from the actions I have described. An excessive current can only be reached in the short-circuited coil after the requisite reversal has taken place. Take Fig. I. If the brush does not break at the instant here depicted, the current in the armature coil A^2 will rise above the value of half-armature current, a back

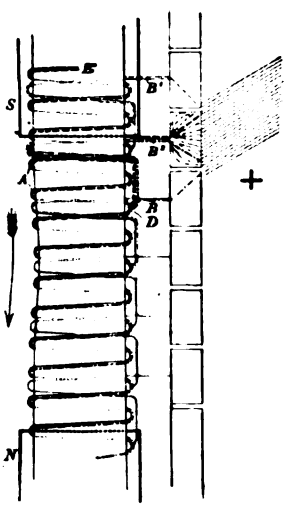

Fig. 5.

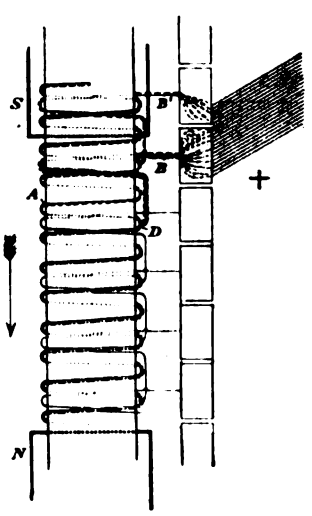

Fig. 6.

current being started in B^2 which flows round through A^2 and B to the brush, and may be considered as superimposed upon the half-armature current in A^2 and B; when the break occurs there will, therefore, be a spark, which, it may be noted, will tend to maintain itself as an arc across the insulation between C and C^2. This excess current in A^2 and B, then, only occurs after the reversal of the section has been duly accomplished—that is, when the reversing of the section has been carried too far. Now, moving the brushes back so that the coil is short-circuited in a slightly weaker field would at once correct this fault. We must, therefore, conclude that if with a given load there is no sparkless position for the brushes of a machine, it is because the coil which has been short-circuited under the brush comes mechanically into the circuit with too little or no current in it, or, in a very bad case, even with the current still in the wrong direction; in other words, the reversal has only been partially effected, or not effected at all, by the inductive action of the field. If in an ordinary machine (speaking of generators) the brushes are shifted backwards so that the armature coils are short-circuited while cutting lines of force of such direction as not to tend to reverse the current in them at all, but rather to increase it, the reversal is only accomplished by the mechanical make-and-break action of the brushes and commutator sections, and is, consequently, accompanied with violent sparking. I think it is abundantly clear, then, that excess of current in the coil which is commutated is never, in practical work, the cause of sparking, but that, on the other hand, sparking which cannot be got rid of by shifting the brushes forward is due to the current of the coil being too small when the break occurs between the commutator section and the brush.

It is still the practice with some makers to use driving-pins at intervals, causing a greater angular space between some of the armature sections than the normal, and the consequence is that the brushes cannot be in the correct position for all the armature coils at the same time. Such machines will invariably be found to be marked at the commutator in a manner regularly increasing and decreasing in relation to the position of the driving-pins: *the marking will be more or less distinct according to the nearness to the same position in which the brushes are set from time to time for the same loads;* because, if in such machines the brush is shifted through a small angle, the sparking is transferred from some sections to others, so that if the brushes are moved about sufficiently the sections will all get marked alike. When the pins are necessary there seems to me to be a very simple remedy for the defect under consideration. I suggested this remedy to Mr. Crompton about 18 months ago, but I no not know whether he has made any experiments with it. The remedy is to make the divisions in the commutator to correspond with the divisions of the armature sections. Thus, in the position corresponding to the position of a driving-pin, there would be a commutator bar having an angular width equal to the normal width of a section, *plus* the angular width occupied by the driving-pin. For good appearance the width of pin might be equal to the angular width of the commutator section, and a dummy section connected to one of its neighbours put in the commutator at the position corresponding to the position of the driving-pin.

Before describing the special means by which I secure the sparkless reversal of the section under the brush at any desired place between the horns of the pole-pieces, I may briefly state the characteristic features of the new machines which the use of the

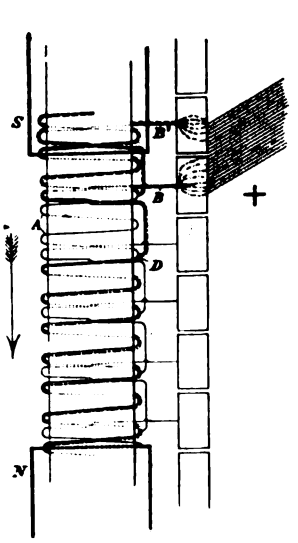

Fig. 7.

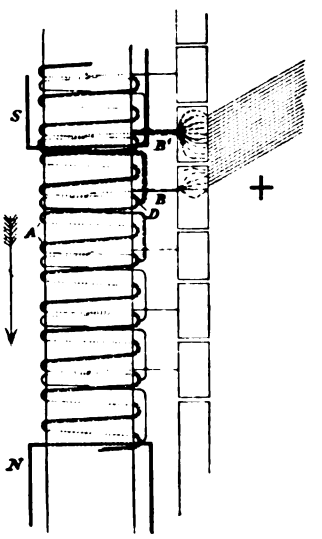

Fig. 8.

devices referred to has enabled me to design. These are as follows:—The air space is a mere clearance—1 millimetre. The reversal of the sections is effected by inductors, or coils, which I have called "commutator coils," independent of the main winding; these commutator coils are so arranged as to be acted on by the pole-tip which is strengthened by the armature current, and the brushes of the machines when run as generators are set with a backward lead instead of a forward one. The commutator coils enabling me to reverse the armature sections just after they have emerged from under the strengthened pole, the result is that what have hitherto been called back turns of the armature winding become forward turns, and the effect of the cross induction is to increase the reversing field instead of to diminish it and the manner they operate in producing it.

The machine illustrated in diagram No. 9 has all of these features. It is self-exciting by means of the armature winding only—that is, it generates a current—behaving like a series machine, of course—without any winding at all upon the magnets, which may, therefore, more properly be called keepers; and it runs absolutely without spark at the brushes.

Before further describing this particular machine, I will describe as clearly as I can the means which I adopt for obtaining these results. Figs. 5 to 8 represent diagrammatically a ring armature machine wound with "commutator coils" for causing the reversal of the armature sections close against the horn, which is strengthened by the armature reaction. The commutator coils consist of coils wound around the armature core, and each connected at one end to the main winding at points between the sections, and at the other end to the commutator segments. There are thus as many commutor coils as there are sections in the armature. The commutator coils are placed at an angular distance from the sections of

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the winding between which they are connected, being from one to two sections nearer the pole horn, which is strengthened by the armature current. The direction of winding of the commutator coils relatively to the main winding is such that if the winding is followed around the core from a point in the main winding under the "flux" horn—which I have ventured to name the horn which is strengthened by the armature current—in the direction which leads out from under the tip of the horn to a point where a commutator coil branches off, and the commutator coil is then followed, the wire leading to, and forming, the commutator coil doubles back under the flux horn, and is then wound around the core in the same direction as that followed when tracing the main winding. This will be seen clearly on referring to Fig. 5. Starting from the point E, and following the main winding down to the point D, then passing up commutator coil B, it will be seen to pass around the core in the same direction as the main winding. Figs. 5, 6, 7, and 8 represent four stages in the commutation of an armature by means of my commutator coils, corresponding to the four stages represented in respect of ordinary winding in Figs. 1, 2, 3, and 4.

In the following description it will be seen that the actions depend essentially upon the difference of pressure induced in the two or more commutator coils concerned at any time, and it follows that the angular distance between the coils must be considerably greater than the length of the air space, otherwise the difference between the E.M.F. generated in the two bars may be insufficient. This necessity, of course, fits admirably with the conditions in short air-space machines. I have, indeed, made no experiments up to the present with the device on smooth-core armatures, but when used on such machines I think it would be necessary to *reduce* the number of sections in the armature to less than the usual practice, so as to get a sufficient distance between the two commutator coils or bars to produce the required preponderance of pressure in one of the two or more segments under the brush.

Fig. 5 illustrates the approximate conditions when one commutator plate is central under the brush. The red half of the armature current meets the blue half at the point D, whence the whole current passes by the commutator coil B to the brush; and it will be noted that as the coil B is just under the tip of the pole horn, the E.M.F. due to one turn is generated in it, and is added to that generated in the main winding. This being the case at the other brush also, the effect of the commutator coils in increasing the E.M.F. is equal to that produced by four of the main conductors on the periphery of the armature. Fig. 6 represents the armature a quarter section further on than Fig. 5. The commutator coil B having moved away from the pole-tip, and consequently into a weaker field, has less E.M.F. generated in it; there is also a fall of potential throughout its length due to the resistance of the conductor. The commutator coil B^1, however, which is now in contact with the brush, is still under the pole, and B and B^1 are united at their inner ends by the main winding, section A. Now the main winding, section A, although yet a considerable distance from the neutral zone, is cutting few lines of force compared with a coil under the flux horn. Under these conditions, then, the current which was flowing in B is transferred to B^1, under the action of the resultant E.M.F. in the circuit composed of armature coil A and commutator coils B and B^1 completed by the brush.

Fig. 6 shows the instantaneous condition a quarter-section further on than that shown in Fig. 5, half the red half of armature current flowing through B^1, the other half flowing through the armature coil A and joining the blue half at D, and thence through B to the commutator. Fig. 7 shows the point half a section from the starting point depicted in Fig. 5, where the current in the armature, section A, is at zero value, the red half of armature current flowing out by B^1 and the blue half by B.

Fig. 8 shows a point three-quarters of a section from the starting position, when half the blue half is still flowing to the brush *via* B, while the other half has commenced to flow around A (thus starting the current in the required direction in A); arriving at the point D, it joins the red half and flows through B^1 to the brush. Fig. 5 may be regarded as the next stage, the armature having moved through an angular distance equal to one section; the current in B^2 (which we regard as B moved one section on) is almost extinct; A is carrying nearly the normal = half armature current, and by the time the commutator segment breaks with the tip of the brush the current flowing from it will be zero, and the break consequently sparkless.

Proceeding now to consider practical applications of my device, Fig. 9 represents diagrammatically the first machine made self-exciting by means of the armature winding alone. The machine

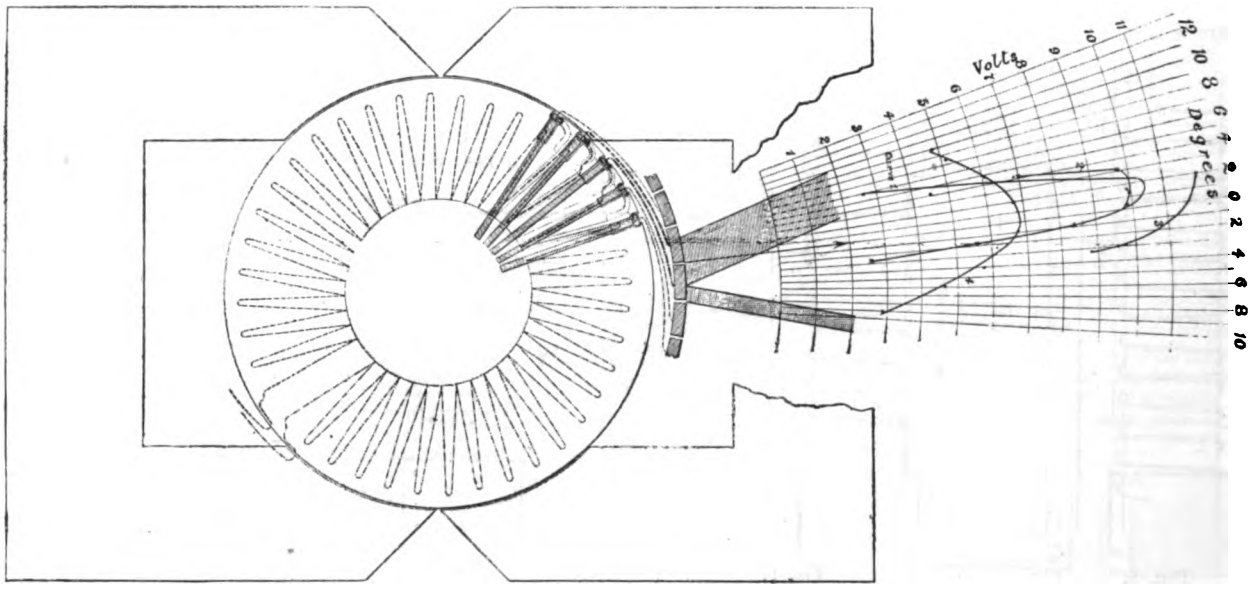

FIG. 9.—Diagrammatic Representation of Dynamo without Winding on Magnets.

is now running at the Bradford Station Hotel, Midland Railway, as a regulator. It is coupled direct to a shunt motor, and driven at constant speed. The main current to the hotel is passed through the armature, causing an inductional proportional to itself, and thus raising the pressure in proportion to the current flowing, and compensating for the drop in the leads, just as a series machine would do under the same conditions.

Particulars and dimensions of the machine are as follows:—

Armature—ring form.	
Diameter, external	9⅜in.
,, internal	4¼ ,,
Length	9 ,,

The periphery has 40 slots cut into it in which the conductors are placed. The slots are ⅜in. deep, ¼in. wide, and each has two grooves cut in it opposite to each other near the top. The main winding conductor is of copper strip 0·15 × 0·5in., and occupies the space in the slot below the grooves. The commutator coils or bars are of copper 0·1in. × 0·3in., with rounded edges, insulated D.C.C., then double-lap tape. They are slid into the slot from one end, their edges fitting into the two grooves. Thus they serve to hold the conductors in position, and so obviate the necessity for binding. The air space is 1 millimetre.

The keepers (they really are not field-magnets) are of double L shape, and made up of charcoal iron plates to prevent heating from the variation of the flux over the polar surface caused by the slots in the armature. The keepers are separated in the centre in order to reduce the cross induction, which is, of course, very considerable. I have had in mind trying Prof. S. P. Thompson's suggestion of

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making the keepers (F.M.'s) up of separate plates, with the object of reducing cross-induction. In subsequent machines the necessity for laminating the polar surfaces has been obviated by putting the conductors into tunnels, and only running a saw-drift through the crown of the tunnel to break the iron circuit and reduce the self-induction of the section; the well-known device of winding over with charcoal iron wire has also been used.

On testing the machine illustrated in Fig. 9, it was found, as I expected, to be self-exciting, and it will carry a current of 400 amperes at 14 volts running at 900 revolutions per minute. It is capable of running with this current absolutely without spark at the brushes. There is hardly any external field—sufficient, of course, to move a compass, but hardly enough to feel with a piece of iron—except between the two keepers in the space marked F, where there was considerable field, due, of course, to cross-induction.

According to Mr. Esson's formula, the output should be $(20{\cdot}5)^2 \times 22{\cdot}5 \times 15 \times 0{\cdot}048 = 7{,}000$ watts. The comparatively small output obtained—5,600 watts—is accounted for by the fact that for the purpose for which it was designed (to act as a regulator) it was necessary to keep the induction density in the iron below 10,000 in order that the E.M.F. should be, as nearly as possible, proportional to the current.

Fig. 10 is the characteristic curve of the machine—the horizontal distances representing the current, the vertical distances the volts.

The most remarkable feature observed about the machine when self-exciting is its extreme sensitiveness with regard to the position of the brushes, a very small movement causing a great variation in the volts. Moreover, it will not excite at all unless the brushes are within a certain arc of about 9deg., the position of this arc corresponding with the position in which the hindermost commutator bar under the brush is under the pole-tip, and the foremost one has passed out from under it.

The curves to the right of the brush in Fig. 9 represent the volts observed with the brushes in various positions. The pointer drawn through the brush indicates the point in the curve corresponding with the brushes in the position shown. Thus, if the brush and pointer were shifted in either direction, the pointer would indicate the volts corresponding with the position of the brush.

Curve No. 1 is plotted from results obtained when the machine was running at a speed of 850 revolutions per minute, and an external resistance in circuit of about 0·03 ohm, the maximum current reached being about 340 amperes. For curve 2 the speed was 1,000 revolutions per minute; external resistance, 0·038 ohm; and maximum current, 291 amperes. Curve 3 shows the effect of one turn of series winding around each keeper, with speed 1.000; external resistance, 0·0455 ohm; current, 202-265 amperes. Curve 4 shows the effect of moving the brushes when a constant current is passed the through armature: speed, 1,000; current, 200 amperes. These curves are plotted from the tables I., II., III., IV., given on next page.

It will at once be obvious to all that a shunt machine with armature on my principle may be made to keep pressure constant with varying current, part of the armature winding performing the function hitherto performed by the use of series coils on the magnets. As would be expected, the armature coils so used are several times more effective, turn for turn, than an equal number of series coils upon the magnet. First, they count double, because they would exist as *back* turns if the machines were running with a forward lead; and, second, because, whereas in the latter case the effect of the series coils—or, rather, of the remainder of them after subtracting the number of the back turns—depends upon the permeability of the field-magnets and armature, and all magetic leakage is, of course, ineffective, the action of the forward turns on the armature when running with a backward lead, though depending on permeability of the armature core and magnets, is wholly effective, even the leakage (if we so call the lines which do not pass around the magnet cores) being necessarily cut by the conductors on the armature.

Particulars of such a machine are as follows:—

Particulars of 9-unit Shunt-wound Dynamo; 100 Volts, at 920 Revolutions per Minute.

Armature—

Diameter at bottom of slots, $6\frac{7}{8}$in.
Diameter of hole in centre of discs, 2in.
Diameter over all, 9in.
Length of iron core, 10in.
Dimensions of slots, $1\frac{1}{16}$in. deep by $\frac{1}{4}$in. wide.
Number of slots, 40.
Total turns of main conductor on armature, 80.
Turns per section of armature, 2.

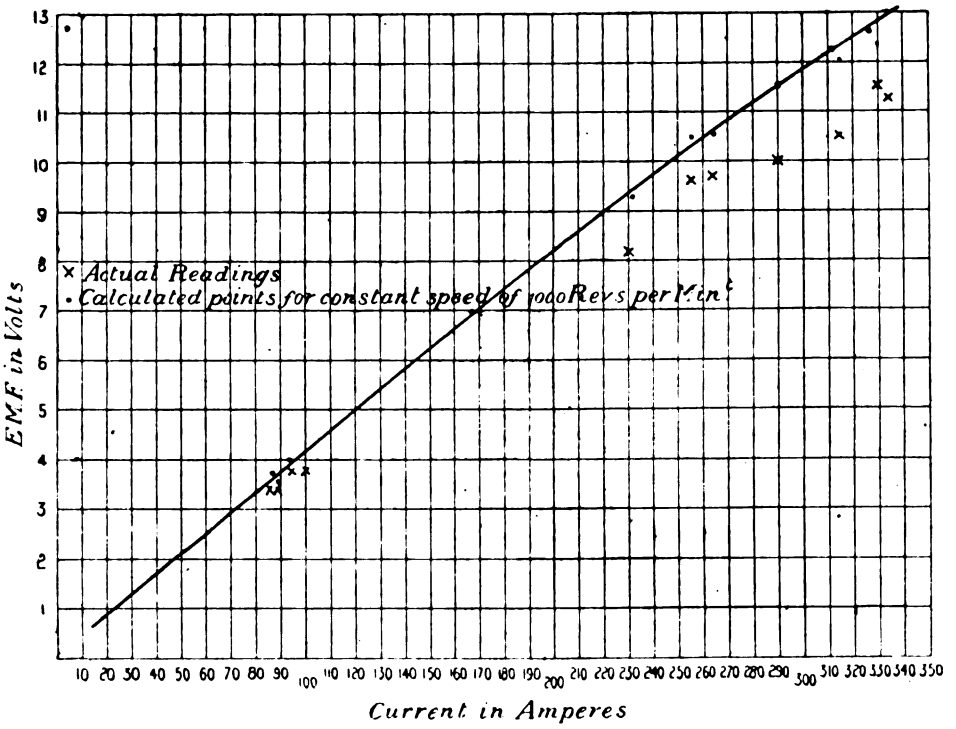

Fig. 10.—Characteristic of Self-exciting Dynamo without Winding on Magnets.

Commutator Coils—

Turns to each section of armature, 1.
Sectional area of main armature conductor, $0{\cdot}180 \times 0{\cdot}160 = 0{\cdot}0288$ square inch.
Sectional area of commutator coils, $0{\cdot}180 \times 0{\cdot}08 = 0{\cdot}0144$ square inch.
Resistance of main conductor between points of connection to commutator coils at T. = 100°F., 0·025 ohm.
Resistance of two commutator coils in series, being the maximum resistance added by these coils to armature, at T. = 100°F. = 0·005 ohm.
Total resistance of armature, 0·03 ohm.

Weight of main armature conductor	35·4lb.
,, of commutator coils	8·8lb.
Total weight of armature conductor.....	44·2lb.

Commutator coils one section in rear when running as generator of armature sections to which they are connected.

Field Magnets.—

Cores of scrap iron, 6in. thick by 10in. broad. Cast 3in. into sole plate at lower ends. Sole plate, therefore, acts as yoke, and has approximately double the sectional area of cores.

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Bore of pole-pieces, $9\frac{7}{16}$in.
Angle subtended by polar face, 130deg.
Length of wound portion of magnet cores, 8in.
Winding, 120lb. No. 18 S.W.G. (0·048in. diameter).
Resistance, 70 ohms.
Total turns, about 5,120.
Ampere-turns in shunt winding, 7,300.
Current through shunt coils, 1·43 amperes.
From the foregoing we get the following in C.G.S. units :—

Armature—
Effective area of core, allowing for 5 per cent. occupied by paper, 297 sq. cms.
Total induction through armature core, 4,000,000.
Density, I = 13,400.

Field Magnets—
Total induction through magnets, assuming leakage coefficient of 1·2 = 4,800,000.
Density, wrought iron, I = 12,400.
,, cast iron, I = 6,200.
,, air space, about I = 6,700.
Magnetising force required :

Air space (2 l. = approx. 1 cm.) = ...	5,350	ampere-turns.
Armature core.....	320	,,
Magnet cores	828	,,
,, yoke	642	,,
Total	7,140	,,

This machine was not originally designed to be self-regulating when running with a backward lead, and, consequently, the width between the magnet cores only allows of an angular breadth embracing 2½ to 3 sections of the armature to assist the forward induction. In Fig. 10, curves 1 and 2 show the performance of the machine as a generator when run with backward and forward

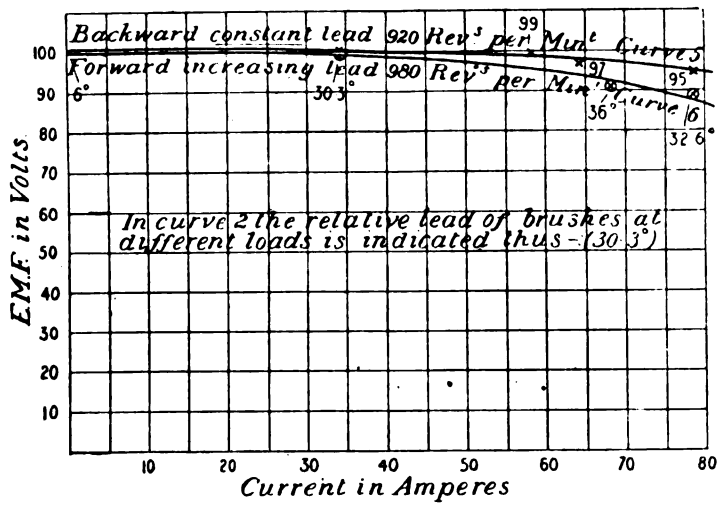
Backward constant lead 920 Rev's per Min. Curves
Forward increasing lead 980 Rev's per Min. Curve 16
In curve 2 the relative lead of brushes at different loads is indicated thus - (30·3°)
EMF in Volts
Current in Amperes

Fig. 11.

lead. With backward lead the position of brushes remains unchanged with all loads. The E.M.F. on open circuit is 100·5 volts at 920 revolutions per minute, at full load 95 volts. Thus, allowing 3 volts for drop in armature and brush connections, the E.M.F. generated at constant speed of 920 revolutions per minute is 2·5 volts less with full load than on open circuit. With forward lead the E.M.F. is 100 volts on open circuit at a speed of 980 revolutions per minute, and 88·8 volts at full load. Allowing 3 volts for drop, as before, the E.M.F. generated is 8·2 volts less with full load than on open circuit, and the brushes require shifting through a total angle of about 35deg. between no load and full load.

Tables V. and VI. give the readings from which the curves 5 and 6, Fig. 11, are plotted. In the experiment the E.M.F. was kept as nearly as possible constant, the results with constant speed being calculated therefrom. Run with a forward lead the machine displays the drop inevitable with a rather short air-space.

I think I am, perhaps, entitled to say that all the machines I have made have been made to fill orders, which they have successfully done. So far, my experience has been that the shorter the air-space the better as regards sparking and fixity of the collecting position. If solid magnet cores are used, as they must usually be on account of the expense of laminated cores, the length of the air-space is limited by the width of the slots. In this connection I have found that the slots may be 1·5 times the length of air-space without any appreciable heating of the poles or waste of power from eddy-current in them. If the armature is wound over with iron wire of sufficient thickness compared with width of slot, or if

Table I.

Speed.	E.M.F.	Current.	Position of brushes*	Remarks.
1,062	0·83	—	+ 2·93°	—
1,058	3·27	89	0	Sparkless.
1,065	3·63	105	0	,,
1,019	11·2	291	0	Slight sparking.
1,035	10·23	260	+ 0·6°	,, ,,
1,055	4·68	175	- 2·34°	Sparkless.
1,062	2·83	78·14	- 3·8°	,,
1,007	9·28	242	+ 2·93°	Slight sparking
1,059	3·53	92·5	+ 4·4°	Sparkless.
1,045	3·53	92·5	+ 4·4°	,,

* The zero position of brushes is indicated in the diagram Fig. 9. The sign + in front of the figures indicates that the brushes were in front of the zero position ; the sign - that they were behind the zero position.

Table II.—All Results are Means of Three Readings.

Speed.	E.M.F.	Current.	Position of brushes.	Remarks.
847	5·6	189	+ 1·15°	Sparkless.
850	8·35	289	0	,,
850	9·9	321	—	Slight sparking.
850	10	340	+ 2·3°	,, ,,
850	9·76	326	+ 4·6°	Sparking.
850	7·1	237	+ 5·75°	—

Table III.

Speed.	E.M.F.	Current.	Position of brushes.	Remarks.
1,016	12·1	265	+ 0·6°	Sparkless.
1,032	9·2	202	+ 0·6°	,,

Table IV.—Means of Three Readings.

Speed.	E.M.F.	Current.	Position of brushes.	Remarks.
988	5·8	198	+ 2·93°	Sparkless.
972	6·35	200	+ 4·4°	,,
991	6·1	200	+ 4·4°	,,
996	5·66	199	+ 6·72°	Slight sparking.
1,005	4·6	199	+ 8·8°	More sparking.
1,013	2·92	194	+11·7°	Slight sparking.
984	6·7	204	+ 2·93°	Sparkless.
991	6·78	207	0	Slight sparking.
994	6·1	206	- 2·93°	More sparking.
1,002	5·21	204	- 5·85°	Sparking under brushes.
988	4·86	205	- 7°†	Slightly more.

† If moved further back serious sparking occurs, so that carbon brush gets red hot.

Table V.

Speed.	E.M.F.	Current.	Brush displacement relative to position at no load.
918	101	0	0
920	100	0	..
928	101	34	...
942	103	35	...
906	100	58	...
916	100	58	...
940	100	57	...
966	101	62	...
964	100	80	...
964	99	78	...

Table VI.

Speed.	E.M.F.	Current.	Brush displacement relative to position with backward lead.
978	97	0	6·6°
940	98	0	6·6°
1,002	100	35	30·3°
990	102	34	30·3°
1,120	100	72	36·0°
1,120	108	65	36·0°
1,078	98	78	32·6°
1,116	100	79	32·6°

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the conductors are in tunnels, the length of the air-space can be fixed having regard to mechanical considerations only. In this connection, however, it is necessary to take into consideration the unequal pull of the keepers, or magnets, if the armature is a little out of centre ; for, unless the shaft is very stiff, this may be sufficient to cause the armature to touch against the keeper when excited.

My machines, made by Messrs. Mavor and Coulson, of Glasgow, of course, run with a forward lead as motors, the forward armature turns still increasing the induction. I have, perhaps, hardly laid sufficient emphasis upon the fact that increase in the armature current increases the strength of the flux-horn, and so tends to automatically bring about the sparkless reversal of the sections without any shifting of the brushes. I think it will be abundantly clear that, so far from having fully described what may be done by means of my device for bringing the commutation of ring and drum armatures under independent control, I have only touched on the border of a new field of design for continuous-current machines.

PARLIAMENTARY INTELLIGENCE.

Edinburgh Improvement Bill.

This Bill came last week before the Police and Sanitary Regulations Committee of the House of Commons, presided over by Mr. Walter Long. Mr. Balfour Browne, Q.C., Mr. Cripps, Q.C., and Mr. Comrie Thomson (instructed by Mr. A. Beveridge) were counsel for the Edinburgh Corporation ; and Mr. Pember, Q.C., and Mr. Moulton, Q.C., appeared for the only petitioners, the National Telephone Company, who claimed to have provision inserted for their protection against and compensation for damage.

Mr. BALFOUR BROWNE, in stating the case for the Bill, said that with regard to Clause 24, providing for the alterations of sewers and gas and water pipes, and interference with wires or other apparatus laid down for telegraphic or other purposes, the National Telephone Company, who were now the only petitioners against the Bill, had overhead wires in Edinburgh attached to certain posts, which were erected on private property, and they came before the Court of Referees and asked either to be put in Clause 24, so that if their wires were touched they might get compensation for damage, or to get a separate clause giving them protection. The Chairman of that Court said he did not regard these people as landowners, or as having any lease or easement in land. They were mere licensees, but they were carrying on their business lawfully, and their wires were in a lawful situation, from which they could not take them down. What they were proposing to do was not something which in the ordinary sense might prejudicially affect their wires without touching them, but they were positively going to physically interfere with them and take them down, and the question was whether that did not give them a reasonable right to be heard. A *locus* was given, but he (Mr. Balfour Browne) asked the Committee to refuse the request of the petitioners, and he defied his learned friend to show any law which gave the licensee any compensation. There were only three cases in which their wires would be affected by the Bill. In one case, the property belonged to the Corporation, which could take away their licence at pleasure. In the other two cases the licences were only for a few weeks or months. The importance of this case was that, if the Telephone Company got a compensation clause, the Committee would be practically stepping in between the licensee and the licensor, and giving the former a right beyond what the latter gave him. The claim was an absolutely new departure. This Telephone Company was spread all over the country, and in the case of every other town they would be able, if they succeeded now, to demand the same right. The Corporation, if they purchased the two other properties by agreement, would be in the same position as the landlords, who could withdraw the licences they gave without compensation. Under the circumstances, he asked the Committee not to give the Telephone Company any protection whatever.

Mr. COOPER, borough engineer, was then called with reference to the petition of the National Telephone Company. In reply to Mr. Balfour Browne, he said in only two cases would the taking down of property by the Corporation affect the Company. The other case where they were affected was the City Chambers, which it was not proposed to pull down. It was the general practice of the Company to take periodical licences to put up the posts, but he understood there were cases in which they had put the up without leave. If they got a compensation clause inserted, they would be able to get compensation in all cases, whether they had a licence or not. At present the Corporation could carry out improvements without being liable for compensation to the Telephone Company.

Mr. JAMES HALL, house agent, Palmer's-buildings, Edinburgh, examined by Mr. Browne, said he had property passing through his hands of the value of £30,000 a year, and he had frequent applications from the National Telephone Company for permission to make attachments of wires. The general nature of the arrangement made was that the Company upheld the roof and paid a small annual sum, and were always subject to removal. In the case of 76, West Port, to the best of his knowledge the Company did not get permission. They took it. He had a letter to that effect from the owner. He managed the property for the owner, who never interfered. He had acted for the owner since 1882, and made the arrangement personally with the Telephone Company in 1889. As a matter of fact, he had challenged the Company with having put up their poles there without leave or licence, and they admitted it, and came to the arrangement of 1889. Under that arrangement they were subject to removal on a few weeks' notice.

By Mr. PEMBER : Is it true that if the owner had wished, the Company might have been turned out at any time between 1882 and 1889, and as a matter of fact the Company have been there since 1882 ?—Yes.

Mr. BALFOUR BROWNE said he did not propose to call further evidence on this point.

Mr. PEMBER then addressed the Committee for the Telephone Company. He said that the business which the Company transacted was a branch of the public business of the Post Office. Quite early in the history of telephones, when there was an attempt to carry on the business as an ordinary enterprise, the Post Office interfered, took the Company into the law courts, and obtained a decision, since upheld, to the effect that telephony was a branch of telegraphy, that telegraphy was a branch of the business of the Post Office, and that the Post Office as a department had a monopoly of the whole of that class of business. Consequently, the telephone companies took out licences, and became the licensees of the Post Office, to transact that particular branch of the public service. The enormous development of telephonic business made its continuance and easy performance of great importance, first to the Company and next to the public. He admitted that they were not statutory companies, because they had found that an Act of Parliament for their purposes was not necessary. Their system—the cheapest and best they could think of—was to work by overhead wires, and for that they needed no Act of Parliament, because the wayleaves enabled them to manage the thing without application to Parliament. They relied on their common-law rights, and had fixed their wires on houses, and carried them along streets, and so forth. Sometimes they arranged for those licences for a term of years. Certainly, in other cases they were only tenants-at-will. It was impossible for them to have any other tenure. A house-owner would never give a seven, fourteen, or twenty-one years' lease to those wires over his house, because he never knew what he might want to do with his property. The Company were perfectly ready to run such risk of disturbance. But when they came to the case of a public body requiring a Parliamentary power to interfere with them, the question was altogether different. There could be no doubt whatever that the powers sought by this Bill involved serious disturbance to the Company's property and business. This Committee was not concerned with investigating the Company's tenure of the buildings affected. It was sufficient for the Company to say that they were carrying on an extensive and valuable business both for themselves and the public, and that this Bill was for the purpose of demolishing buildings on which the Company depended, and altering streets across which they carried their wires. The contention of the Corporation was that the Company's property they might destroy without compensation. His answer to that was two-fold. First, that the Corporation was not the private owner, and therefore could not do it without Parliamentary powers ; and, secondly, that the private owner would not do it. He submitted that Parliament would not grant powers which would disturb or destroy people's property without granting compensation. It was no answer to say that the Company's property was not statutory property. He had never heard that compensation was confined to statutory property. They owned their property at common law, and common law right was as good as statutory right in this respect.

Mr. BALFOUR BROWNE, in replying, pointed out that the Bill took power to disturb water and gas pipes, but did not seek to disturb wires at all. It was because the Corporation would become the owners of certain property on which a number of wires were fixed that they sought to exercise the rights of owners, and give the Company notice to remove. But what the Company asked was to give them as lessees rights of compensation against the landlord, their lessor. Now, the rule was that compensation was given only in cases where an action would lie. If no action could lie, there could be no compensation ; and that was the case here. But if his learned friend was right, and there was a property for which he was entitled to compensation, he would get it, because the Bill incorporated the Lands Clauses Act.

At this point, after a brief consultation with his colleagues,

The CHAIRMAN said that the Committee did not desire to hear anything more. They were not prepared to entertain the petition of th Telephone Company.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, May 19th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Students' Meeting. Paper to be read : "Primary Batteries in Theory and Practice," by William R Cooper, M.A.

THURSDAY, May 25th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Paper to be discussed : "On the Prevention and Control of Sparking of Continuous-Current Dynamos without winding on the Field Magnets ; and Constant-Pressure Dynamos withou Series Winding," by W. B. Sayers, A.I.E.E.

FRIDAY, May 26th.

PHYSICAL SOCIETY.

5 p.m. Ordinary Meeting. Papers to be read and discussed : (1) Discussion upon Dr. Lodge's Paper—"The Foundations of Dynamics" ; (2) "A New Photometer," by A. P. Trotter ; (3) "Notes on Photometry," by Prof. S. P. Thompson, F.R.S. ; (4) "Exhibition of a Vibrating Bar," by C. J. Woodward.

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(The Oldest Electrical Journal.)

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.
Editorial, Publishing, and Printing Offices :
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.
Telephone No. 2714. *Telegrams :* "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed "Coutts and Co."*

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DIRECT-CURRENT DYNAMO DESIGN.

Until the reading of Mr. W. B. SAYERS' Paper at the Institution of Electrical Engineers last week, no radical improvement in the design of direct-current dynamos had been suggested for some years, and manufacturers had begun to think that a state of finality had been reached. The limiting conditions of output were admitted and accepted as inevitable. Heating was practically reduced to the lowest possible amount by lamination of both iron and copper. The demagnetising effect of the armature was easily calculated, and kept within bounds by attention to the length of the air gap and the magnetic density, and the energy wasted in the field excitation was reduced to a minimum. The commercial efficiencies obtained were so high as to leave practically no margin for advance, and the only real difficulty was the sparking. This could be controlled within fairly well-defined limits, which could not be safely exceeded. Electricians, however, were fully alive to the various points in which theory indicated a possible improvement, and from time to time patents were taken out embodying more or less radical alterations in design.

Years before the connection between the back ampere-turns, the cross ampere-turns, and the main field was mathematically demonstrated, attempts were made, chiefly on empirical lines, to stop sparking. Amongst these were auxiliary pole-pieces, compound brushes, auxiliary coils wound around the armature or intermixed with the main winding; all of which, although partially successful, were impracticable from mechanical considerations. In 1890 the independent investigations of Mr. SWINBURNE and Mr. ESSON, gave a fresh impetus to the subject, resulting in further devices—such as MATHER'S compensating magnet, SWINBURNE'S reversing series-coil wound round the leading polar edge, S. J. RYAN'S perforated pole-pieces with windings parallel to the axis of the armatures, and the division of the pole-piece by a vertical air

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space through its centre. But still these devices cannot be said to have advanced the subject very much.

Mr. W. B. SAYERS in his Paper read on Thursday of last week before the Institution of Electrical Engineers described an invention which will apparently "make history." The Paper was received by the Institution with more than usual enthusiasm, and members spoke in eulogistic terms of Mr. SAYERS' ingenious device; but we think that they have all rather overstated, in their enthusiasm, its probable field of usefulness. We do not think it clear that the design of direct-current dynamos will be revolutionised or even radically altered by it. Broadly speaking, Mr. SAYERS' invention permits the winding of the series turns on the armature instead of on the field-magnets; and, hence, a series dynamo on his principle requires no field windings, and a compound one only shunt coils. This end is attained by connecting the main loops of the armature winding to the commutator bars by means of long connections, which form open circuits excepting when in contact with the brushes—then they carry the whole armature current. These connections are doubled backwards, with reference to the brushes, and form loops under the edge of the flux pole, thereby producing a forward field and, consequently, tending to excite the magnets. By this means it is apparently possible to control sparking, to reduce magnetic resistance and consequent exciting power, and also to raise weight-output efficiency.

It must be borne in mind, however, that no large machine has yet been built on these lines; and, further, it is not clear that the method is desirable for this purpose; experience may show that though the scheme is suitable for small machines, it may not be adapted for large ones. As was pointed out during the discussion, if sparking can be entirely obviated, the only limit to output is heating. But it is well known that large machines at present give more or less trouble from this cause; and hence it is difficult to see how additional windings, causing a further increase of heat however small, can be desirable. The test of this invention, like that of all others, is merely a question of £. s. d. If by means of it the price of machines can be lowered, it must come; but if the contrary be the case, its use will necessarily be restricted. We remark that Mr. SAYERS has not applied this winding to a smooth-core armature, but has confined his experiments to slotted or tunnel cores. Experience with these cores is so varied that it does not seem safe to form a decided opinion until the method has been applied to smooth ones, where we are at once on safe ground. Yet the inclination of the engineer is decidedly in favour of the tunnel armature, a serious drawback to which, in the experience of some builders, has been sparking. If the device will overcome this, a new era for low-pressure direct-current dynamos is probably before us; but it does not seem probable that high-pressure machines can be safely wound in this manner. Mr. SAYERS says that his machines require short polar arcs in order to increase the belt of back ampere-turns, on which the exciting power depends. This points to a diminution of output, for the magnetic resistance is necessarily increased; yet with a tunnel armature the air-gap is so small that probably this loss will be more than compensated for. In a series-wound machine, since the field-magnets will require no windings, they can be made much smaller than usual; and even with a compound-wound machine, as the field-magnets only have to carry the shunt coils, they may be of small dimensions. Another peculiarity of these machines is the large variations of pressure for extremely small alterations of lead. This property may be of use in the regulation of motors, but appears of doubtful advantage for ordinary constant-pressure dynamos. It is probable that motors embracing this new feature will be utilised in traction problems, and they may assist to solve some of the speed-regulation difficulties.

We expect that the adjourned debate on Mr. W. B. SAYERS' Paper, which takes place on May 25th, will throw further light on this interesting invention. In the meantime, we heartily congratulate the author on the successful application of his ingenious device to small dynamos, and also on the hearty reception of his paper at the Institution of Electrical Engineers.

OBITUARY.

EDWARD ALFRED COWPER.

By the death of Mr. E. A. Cowper, a well-known figure is removed from Westminster, and the already scant number of engineers of the old school is reduced. Only a few weeks ago he was taking part in the discussion at the Institution of Civil Engineers on the Paper by the late Mr. Willans, and characteristically advocated the use of the well-understood Prony brake instead of the rather mysterious dynamo for testing engines, nor did he let the opportunity pass for insisting, as he was wont, on the advantages of the steam jacket. Mr. Cowper died on the 9th inst., from acute pneumonia, after a short illness, at the age of 73. He was the son of Prof. E. Cowper, of King's College, the improver of the printing machine. He served a seven-years' apprenticeship at the works of John Braithwaite, of St. Pancras, which he entered at the age of 14 in 1834. In 1847 he assisted in founding the Institution of Mechanical Engineers, becoming an original member of council, and was President in 1880-81. After active work with Messrs. Fox and Henderson he started in practice as a consulting engineer in 1851, joining in the following year the Institution of Civil Engineers, in the affairs of which he continued to take so active a part up to the last. In about 1857, after giving great attention to the subject of the economy of steam, he introduced the jacketed reservoir for compound engines, with the cranks at right angles. This invention, well known as "Cowper's hot-pot," was applied to H.M.S. "Briton" in 1870; the coal consumption on the trial was 1·3lb. per horse-power per hour. The invention of the tension wheel for bicycles and of rubber tyres in 1868 is attributed to him. Mr. Cowper was a thoroughly practical mechanical engineer, and had strong inventive abilities. He became a member of the Institution of Electrical Engineers in 1879, but did not concern himself much with electrical work. In this year, however, he invented the writing telegraph, an instrument which, as far as the co ordinate movements of rods attached to a tracer; of similar movements of a pen; and of a moving band of paper, are concerned, are identical with the very latest apparatus proposed for this purpose. To all who are in the habit of attending the meetings of the Institution of Civil Engineers, Mr. E. A. Cowper was one of the best known members of council. It was the exception if he did not take part in the discussion on a Paper dealing with a mechanical subject, and he always had some bit of experience to recall, and often an invention of his own to describe with which to illustrate in a most practical manner the topic of the evening. Quite recently he took a keen interest in the display of the diagrams and full-sized models illustrating Mr. Sopwith's Paper on the break-down of the "Umbria," and added greatly to the interest of that discussion. In 1887, in conjunction with Dr. W. Anderson, he made a determination of Joule's equivalent on a large scale, a 5 H.-P. engine being run on a Froude dynamometer for many hours. Mr. Cowper rendered valuable services in connection with the machinery department of the South Kensington Museum, with the Inventions Exhibition, and the Royal Agricultural Society. The times are altering, and such men of mechanical instinct and long experience in a definite branch of a wide profession are becoming rare. The rising generation is more ready to display a knowledge of theory, to spend its strength on the last new thing, and to attempt to cover a wide range; may it give rise to a few men of the sound common sense of Mr. E. A. Cowper.

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CHEAP TRACTION OR DEFECTIVE TELEPHONES.

On 26th ult., a meeting was held at the Board of Trade, Sir Courtenay Boyle in the chair (Sir Joseph Warner, Counsel to the Lord Chairman of Committees, being present), at which the Telephone Company and the Electrical Traction Association were represented. The Telephone Company put it to the Board of Trade that, inasmuch as during the past four years they had opposed some fifty Bills in Parliament, with the result that with one or two unimportant exceptions, clauses for their protection had been invariably given either in the form adopted in 1889 in the Lea Bridge case, or in 1890 in the Plymouth case, the time had now arrived when the Board of Trade should accept one of these clauses as a model clause, and take measures to ensure the insertion of such clauses in all Electrical Traction Bills and Orders without further action on the part of the Telephone Company.

The essential portion of the Plymouth and Lea Bridge clauses is the first paragraph as follows :—

1. The Company shall so construct their electric circuits and other works of all descriptions, and shall so work their tramway in all respects, as to prevent any injurious interference by induction or otherwise with the electric circuits from time to time used or intended to be used by the Telephone Company for the purpose of telephonic communication, or with the currents in such circuits. Provided, that as regards electric circuits erected or laid down by the Telephone Company after the construction of the works of the Company, this sub-section shall only apply if reasonable and proper precautions have been taken in the erection or laying down of such circuits, and if they have not been erected or laid down in unreasonably close proximity to the lines or works of the Company.

Sir Courtenay Boyle having heard the representatives of the Traction Association, intimated that the Board of Trade were of opinion that what had taken place *did not* amount to the establishment of an uniform principle that there should be protective clauses in favour of the Telephone Company. He thought that since 1889 a good deal of knowledge had been gained, and that the Board of Trade would now communicate with the Authorities of Parliament to see whether the matter could be considered and settled, and that in the meantime the Board of Trade would not insert any protection clauses in favour of the Telephone Company.

As an outcome of these communications, a resolution for the appointment of a Joint Committee of Lords and Commons has been passed by Parliament: "To consider and report whether the grant of statutory powers to use electricity ought to be qualified by any prohibition or restriction as to earth-return circuits or by any provisions as to leakage, induction or similar matters, and, if so, in what cases and under what conditions. And if the Joint Committee are of opinion that any such prohibition, restriction, or provision should be enforced, to settle the necessary clauses."

The question for consideration by the Joint Committee is in effect whether the Telephone Company is to have *its present system* protected or not. The form of reference does not at first seem to mean this, but it must be borne in mind that the Telephone Company are at present carrying on their business without statutory authority, and that (save by a general act) Parliament can only legislate by the insertion of clauses into Bills or Orders brought before them by promoters asking for powers to use electric traction. When this Joint Committee meets it is assumed that the whole question of electrical traction and telephones will be considered, and the Committee will either give the Telephone Company the protection for which they ask, or say that any protection shall be conditional upon the Telephone Company amending or altering its system by the introduction of a metallic return or otherwise.

The Telephone Company allege that they have always obtained protection clauses from Parliament since they commenced opposition to those Bills in 1889. This is not quite accurate. Out of 50 cases, protective clauses were inserted in about 40 cases *by consent* (given, no doubt, in many cases to save the heavy expense of a long Parliamentary fight), and it was only in about ten cases that the matter came before the Committee. In the cases fought, the results were by no means uniformly favourable to the Telephone Company.

The evidence given by the Telephone Company may be summarised as follows :—The Telephone Company first showed that the currents used by the Telephone Company were infinitesimal and not likely to do any harm to anybody else. That it was *cheaper* to them to dispense with a metallic return and to take the current back by means of gas-pipes or otherwise, by earth returns. The telephones had been decided to be within the terms of the Telegraph Act, and that, in consequence, telephonic messages, being telegrams, were only a branch of a business which had for fifty years been carried on by means of earth returns, and thereby obtained a prescriptive right to the use of the earth. That the electrical-traction companies quite recently proposed to use earth returns. That the currents required for electric traction were very large and powerful. That leakage from, or the inductive effects of, these currents passing interfered greatly with the telephones. That the Telephone Company's lines could be protected from interference by using a metallic return and twisting the wires. That such steps could, however, only be carried out at enormous and prohibitive cost. That, on the other hand, it was very simple and inexpensive to prevent interference by insulating the conductors used for electrical traction.

The evidence upon which the Telephone Company have heretofore succeeded in obtaining protective clauses will show that the real facts of the case have never been put forward, for it was to the following effect : That the same rules should be placed upon electric tramway cases that had been placed upon the electric-lighting companies. That prevention of leakage to earth was solely a question of expense. That it was perfectly easy to insulate the two conductors in a conduit at an expense of about £40 per mile, whereas to lay down a metallic return to telephone wires would cost an enormous amount.

But electric traction cannot be governed by the rules placed upon electric light, for while nothing is easier than the insulation of electric-light conductors from which the current is taken at fixed terminals, nothing is more difficult than the insulation of electric-traction conductors where the current is taken by the arm of a passing tramcar. In the Folkestone case, where the cost of insulating the tramway conductors was put at £40 per mile, the decision of the Committee was that if the Telephone Company required this done they must themselves pay for it ; but the Telephone Company showed their faith in their witness's estimates by refusing the clause and allowing the Bill to pass without any protection to them. As a consequence, they had to pay the promoters' costs, amounting, probably, to more than the cost (on their estimate) of insulating the tramway conductors.

The telephone service with earth returns is admittedly defective. The use of a metallic return by the Telephone Company is not only possible but would, it is admitted, prevent all interference ; and the only excuse given by the Telephone Company for their failure to make their system perfect by this means is that of expense. On the other hand, it has been shown that the use of electricity as a motive power reduces greatly the necessary cost of tramways, but that in practice it is not possible to insulate the conductors.

The matter resolves itself into the question whether *cheap traction* is to be prohibited in order that a *defective telephone system* may be maintained or whether the Telephone Company should not be compelled to perfect its system, and by that means take away the reproach that its service is not only bad but retards the due progress of other electrical industries. And this is the real question that will have to be submitted to the Joint Committee. *Primâ facie* it may seem that there can be little doubt that the decision will be in favour of the traction interest. But in view of the strong position occupied by the Telephone Company, it behoves all corporations and local authorities and all those who desire to see *cheap traction* encouraged and the telephone service improved to support in every possible way the Electrical Traction Association before the Joint Committee.

R. E. Crompton.
E. Garcke.
Sydney Morse.

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MAGNETIC VISCOSITY.*

BY J. HOPKINSON, D.SC., F.R.S., E. WILSON, AND F. LYDALL.

The following experiments were carried out in the Siemens Laboratory, King's College, London, and are a continuation of experiments by J. Hopkinson and B. Hopkinson, a description of which appeared in *The Electrician*, September 9, 1892. In that paper determinations were given of curves, showing the relation between the induction and the magnetising force, for rings of fine wire of soft iron and steel, through complete cycles with varying amplitudes of magnetising force, both with the ordinary ballistic method and with alternating currents of a frequency up to 125 complete periods per second. It was shown that if the induction was moderate in amount, for example, 3,000 or 4,000, the two curves closely agreed; but if the induction was considerable, for example, 16,000, the curves differed somewhat, particularly in that part of the curve preceding the maximum induction. The difference was greater with steel than with soft iron. It was not then determined whether this difference was a true time effect or was in some way due to the ballistic galvanometer. The present Paper is addressed to settling this point. The ring to which the following

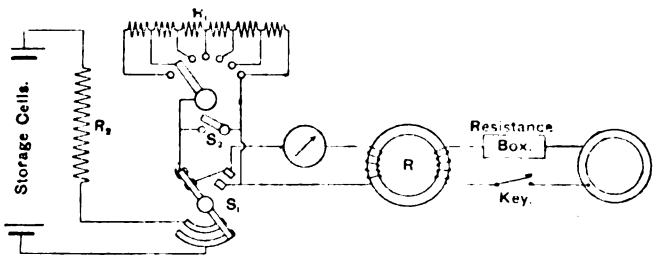

FIG. 1.

experiments refer is of hard steel, containing about 0·6 per cent. of carbon, in the form of wire $\frac{1}{100}$in. diameter, varnished with shellac to insure insulation. The material was supplied by Messrs. Richard Johnson. The ring is about 9cm. diameter, and has a sectional area of 1·08 sq. cm.; it is wound with 200 turns of copper wire, and with 80 turns of fine wire for use with the ballistic galvanometer.

In *The Electrician* paper the static curve of hysteresis was determined by the ballistic galvanometer, the connections being made according to the diagram in Fig. 1, where R is the hard steel wire, B is the ballistic galvanometer, S_1 is a reversing switch, and S_2 is a small short-circuiting switch for the purpose of suddenly inserting a resistance, R_1, into the primary circuit. The resistance R_2 was so adjusted that the maximum current in the primary circuit was such as to give the desired maximum magnetising force on the ring. In taking the kicks on the ballistic galvanometer the method adopted was as follows:—Having closed the primary by means of S_1, the switch S_2 was suddenly opened, thus allowing the

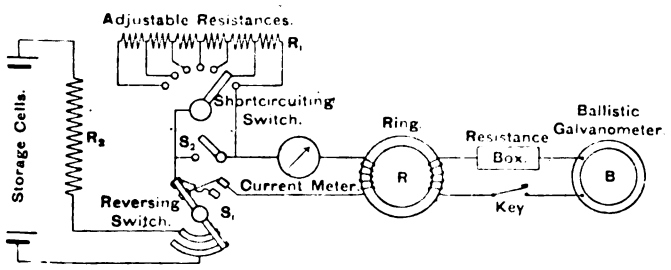

FIG. 2.

magnetising force to drop to an amount determined by R_1, and the kick observed. A total reversal was then taken with S_1, and the kick again observed. The closing of S_2 again brought up the magnetising force to its maximum in the opposite direction to that at starting.

In a letter to the Editor of *The Electrician*, September 16, 1892, Mr. Evershed stated that, "Had the slow cycle been obtained by the method described by Mr. Vignoles,† Messrs. Hopkinson would have found it in almost absolute agreement with the quick cycle curve." To settle this point the static curve of hysteresis was obtained by the ballistic galvanometer, the connections being made according to the diagram in Fig. 2. This is not the method of experiment alluded to by Mr. Evershed, but it is capable of varying the magnetising force in the same way as is described by him. R is the hard steel wire ring, B is the ballistic galvanometer, S_1 is a reversing switch, and S_2 a small switch for the purpose of short-circuiting the adjustable resistance R_1. The difference between this diagram and that in Fig. 1 is that R_1 can be suddenly inserted into the primary circuit by one stroke of the reversing switch S_1. In this way it is possible to vary the magnetising force from one maximum through zero to any desired point within the other maximum by one motion of the switch S_1, which operation takes but a small fraction of a second to perform.

In Fig. 3 the points marked × were obtained by the method in Fig. 1; the points marked · being obtained by the method in Fig. 2. Table I. gives the values for B and H, from which these points

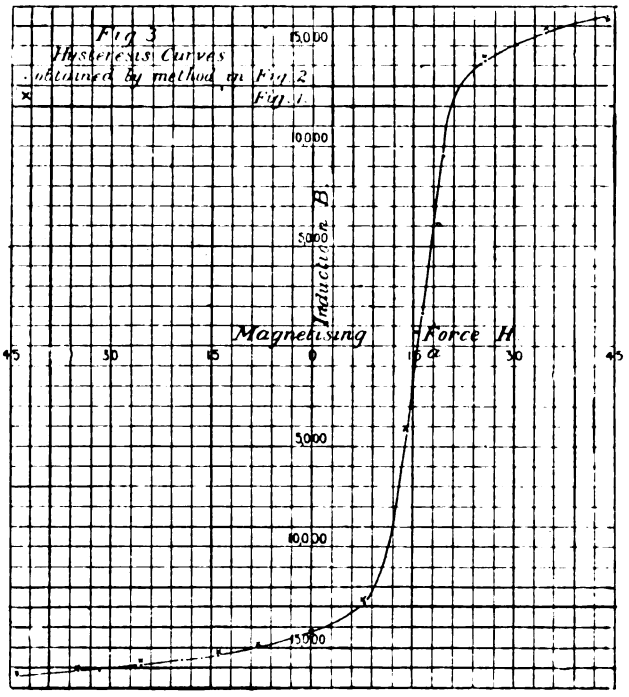

FIG. 3.

have been plotted, and their close agreement proves that the difference found between the static and quick-cycle curves is not due to the cause suggested by Mr. Evershed. In each case the battery used had a potential difference of 108 volts, the periodic time of the ballistic needle being 10 seconds.

Table I—Hard Steel-Wire Ring.

H.	B. Points marked × obtained by method shown in Fig. 1.	B. Points marked ● obtained by method shown in Fig. 2.
+44·12	16,295	16,436
34·77	15,830	15,650
25·44	+14,407	14,290
19·32	—	9,539
16·1	—	+ 1,704
14·2	- 4,045	-- 4,130
7·73	12,690	12,820
0	—	14,280
- 7·73	14,870	14,990
14·2	15,270	15,380
16·1	—	15,460
19·32	—	15,630
25·44	15,733	15,860
34·77	16,033	16,150
44·12	16,295	16,436

It was observed, when taking the hysteresis curve by the method in Fig. 2, that the sum of the inductions found by varying the magnetising force from one maximum to an intermediate point, and from that point to the other maximum, did not exactly equal the induction got by varying the magnetising force direct from one maximum to the other.

To investigate this with the ballistic galvanometer the magnetising force (Fig. 3) was taken from one maximum through zero to the point *a* by one motion of the reversing switch handle, and the galvanometer circuit closed at known intervals of time *after* such change, the deflection being noted. This deflection does not represent an impulsive electromotive force, nor yet a constant current, but is caused by a current through the galvanometer diminishing in amount somewhat rapidly. It might arise from the comparatively slow rate at which the magnetising current changes, owing to the

* Paper read before the Royal Society.
† *The Electrician*, May 15 and 22, 1891.

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self-induction of the circuit, or it might arise from a finite time required to develop the induction corresponding to a given magnetising force. The former would be readily calculable if the ring had a definite self-induction; in our case it is approximately calculable.

Let R be resistance of primary circuit, E the applied electromotive force, x the current, and I the total induction multiplied by the number of primary turns.

$$E = R\,x + \frac{d\,I}{d\,t}.$$

Now I is known in terms of x for conditions of experiment very approximately, and, roughly, $d\,I/d\,t$ has a constant ratio to $d\,x/d\,t$—is equal, say, to $L(d\,x/d\,t)$; hence the well-known equation

$$E = R\,x + L\frac{d\,x}{d\,t},$$

$$x = \frac{E}{R}\,(1 - \epsilon^{-\frac{R}{L}t}).$$

From our curves we see that induction per square centimetre increases 10,000, whilst magnetising force increases 4. Total induction multiplied by the primary turns, taking the volt as our unit, increases $10{,}800 \times 200 \times 10^{-8}$, whilst the current increases $\frac{1}{2}$ an ampere, *i.e.*,

$$L = 4{\cdot}32 \times 10^{-2}.$$

In the experiments made E = 4 and 108 volts and R = 0·8 and 21·6 ohms, whence

$$x = 5\,(1 - \epsilon^{-\frac{80}{4{\cdot}32}t}) \text{ and } 5\,(1 - \epsilon^{-\frac{2160}{4{\cdot}32}t}).$$

In either case x does not differ sensibly from its final value when $t = \frac{3}{5}$ second. Hence the self-induction of the circuit can have nothing to do with the residual effects observed.

These experiments showed that an effect was produced upon the galvanometer needle, appreciable for some seconds, the effect being somewhat more marked with 4 than 108 volts. But the whole amount was so small as to be less than 1 per cent. of the total change of induction; from which we infer that no material difference exists between curves of induction determined by the ballistic galvanometer and the inductions caused by magnetising forces operating for many seconds.

Effect of tapping the Specimen.—Having taken the magnetising force from its maximum through zero to the point *a* as before, the effect of tapping was marked, especially in the case of soft iron, when a kick corresponding to an acquirement of 633 lines of induction per square centimetre was observed.

The following experiments on the hard steel wire ring were carried out with the alternator, the object being to ascertain if a time effect on magnetism exists. The ballistic curve (Fig. 3) has been taken as a standard with which to compare the respective hysteresis curves. In each case the maximum magnetising force has been made as nearly as possible to agree with that used when taking the ballistic curve, and the method of test was that employed in *The Electrician* paper. For the sake of completeness the diagram, Fig. 4, and description are given over again. Quoting from that paper, we have:—"For determining the points on the closed curve of magnetisation given by rapid reversals of the current in the coil, the ring was connected in series with a non-inductive resistance to the poles of an alternate-current generator, or a transformer excited by the generator, thus:—

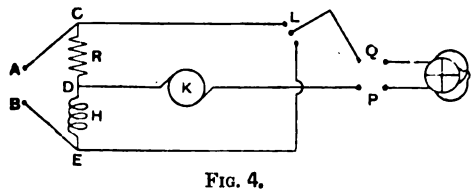

Fig. 4.

in which A B are the poles of the transformer or generator; C D the terminals of the non-inductive resistance R; H the coil surrounding the ring; P and Q the studs of a reversing key connected to the quadrant of a Thomson quadrant electrometer; L a key by means of which Q could be connected with C or E at will; and K a revolving contact maker, through which P was connected to D. A condenser was connected to P and Q, in order to steady the electrometer readings. The contact maker K was bolted on to the axle of the generator. It consists of a circular disc of ebonite, about 13in. in diameter, having a small slip of copper, about $\frac{1}{10}$in. wide, let into its circumference. A small steel brush presses on the circumference, and makes contact with the piece of copper once in every revolution. The position of the brush can be read off on a graduated circle. The quadrant electrometer thus gives the instantaneous value of the difference of potential between the points C and D, or the points D and E, according to the direction of the key L."

Frequencies of 5, 72 and 125 ∿ per second have been tried, two values being given to the potential difference at the terminals of the alternator in each of the frequencies 72 and 125, making in all five complete experiments. The curves so obtained are given in Figs. 8, 9, 10, 11 and 12 respectively. From observations of the values of the electromotive force between C and D (Fig. 4) at different times in the period, a curve A (in each experiment) was plotted, giving the magnetising force in terms of the time; a similar curve was plotted for the electromotive force between D and E, which, when corrected by subtracting the electromotive force due to the resistance of the coil H, gives the potential or time rate of variation of the induction in terms of the time. Hence the area of this curve (B) up to any point, *plus* a constant, is proportional to the induction corresponding to that point. This is shown in curve C, which is the integral of B. In each of the five experiments the ring with the non-inductive resistance was placed across the terminals of the alternator, and the excess of potential taken up by a non-inductive resistance.

In Fig. 5 the hysteresis curves for frequencies of 5, 72 and 125 are compared with the ballistic curve. These curves are marked 5, 72L, and 125L respectively. The corresponding values for B and H, from which these curves have been plotted, are given in Tables II., III., V., which have been obtained from the curves in Figs. 8, 9, and 11 respectively.

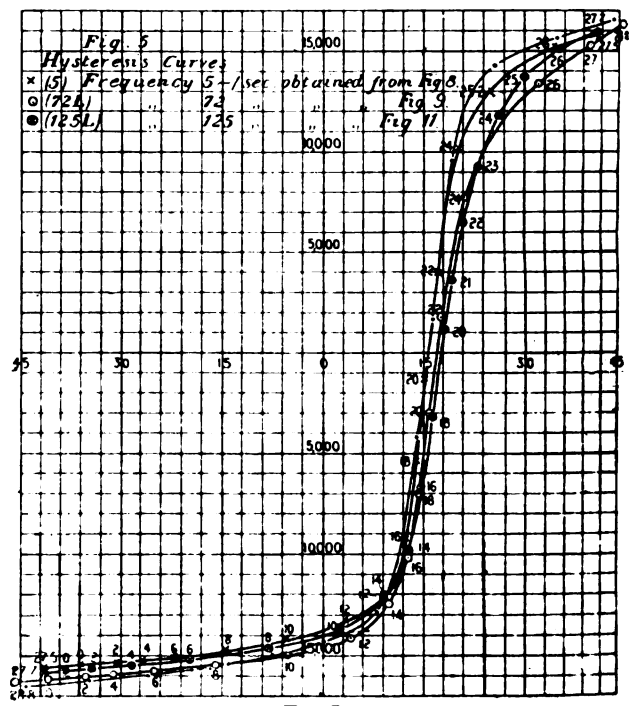

Fig. 5.

Table II.—Frequency 5 per second.

B.	H.	B.	H.
15,660	41·7	13,337	+ 3·4
15,200	34·4	14,382	− 5·6
13,010	25·1	14,747	14·4
10,190	19·95	15,203	22·0
+ 3,970	17·1	15,295	26·85
− 1,230	15·3	15,477	30·86
5,340	14·1	15,523	35·75
9,176	12·3	15,660	41·7
12,007	9·4		

Table III.—Frequency 72 per second. Potential at Terminals of Alternator, approximately 36 Volts.

B.	H.	B.	H.
16,245	+ 45·7	12,506	9·86
16,180	45·5	14,118	4·26
15,215	39·9	14,956	− 5·44
13,410	31·7	15,407	15·86
7,805	21·3	15,729	24·77
+ 1,805	17·8	15,923	31·1
− 3,030	15·8	16,116	35·4
7,027	14·3	16,219	40·9
10,121	12·6	16,245	45·7

The most noteworthy features in these curves are that the curve with a frequency of 5 is very near the ballistic curve, if allowance is made for difference in the magnetising current, and that the

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curves with a frequency of 72 and 125 deviate very materially, particularly in the part of the curve somewhat preceding the maximum induction. Hence, the time effect mainly develops with a greater frequency than 5 per second. Hence also, we infer that this effect, as already described in *The Electrician*, is a true time effect, not arising in any way from the ballistic galvanometer.

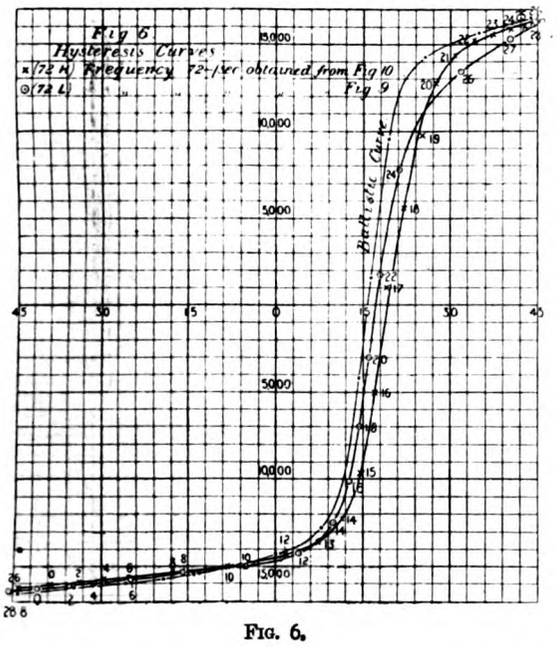

FIG. 6.

In Fig. 6 the hysteresis curves for a frequency of 72 are compared with the ballistic curve. The curves are marked 72 L and 72 H respectively, the potentials at the terminals of the alternator in the two cases being, approximately, 36 and 430 volts. The corresponding values for B and H are given in Tables III., IV., which have been obtained from the curves in Figs. 9 and 10 respectively.

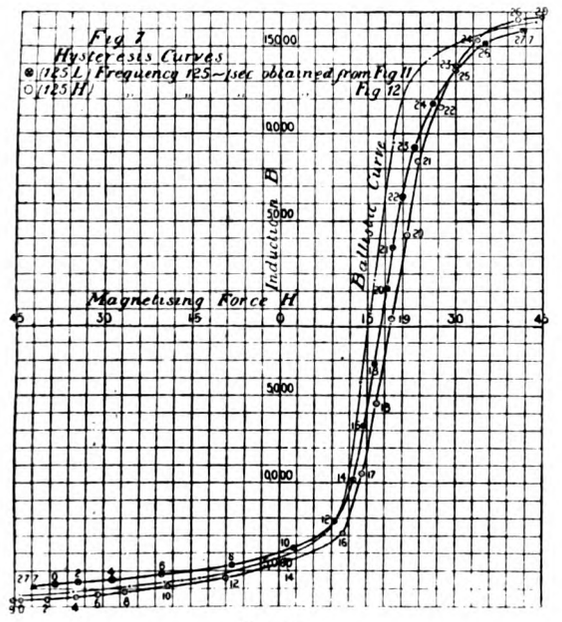

FIG. 7.

The difference between the two curves in Fig. 6 was at first puzzling, but a little consideration satisfied us that it arises from the same time effect. The curve 72 L was determined three times, with the same result. The numerals refer to thirtieths of a half-period. From 26 to 28·8 of the L curve the magnetising force increases from 31·8 to 45·6, whilst from 21 to 26 of the H curve it increases from 30·6 to 44, the rate of change being about double as great in the former case as in the latter, and it is the L curve which deviates most from the ballistic curve. In like manner, in the neighbourhood of zero induction the induction in the H curve is changing twice as fast as the induction in the L curve, and it is here the H curve which differs most. How these differences of rate of change arise can be seen by inspecting Figs. 9 and 10.

In Fig 7 the hysteresis curves for a frequency of 125 are compared with the ballistic curve. The curves are marked 125 L and 125 H respectively, the potentials at the terminals of the alternator being approximately 62 and 750 volts. The corresponding values

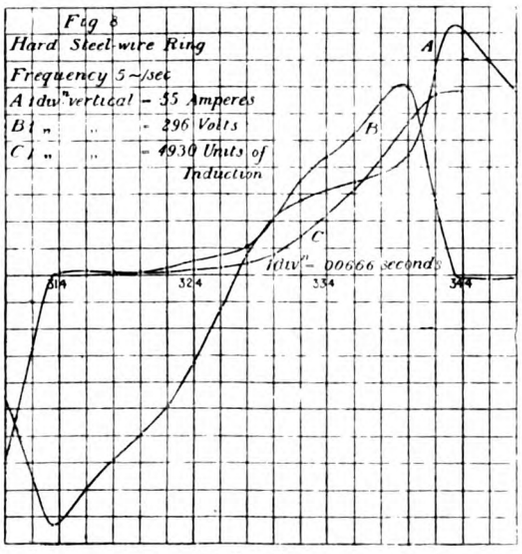
Fig 8
Hard Steel wire Ring
Frequency 5~/sec
A 1div vertical = 55 Amperes
B 1 " " = 296 Volts
C 1 " " = 4930 Units of Induction
1div = .00666 seconds

FIG. 8.

Table IV.—Frequency, 72 per second. Potential at Terminals of Alternator, approximately 438 Volts.

B.	H.	B.	H.
16,221	43·98	9,609	14·36
16,214	44·32	12·300	11·22
16,069	42·75	13,530	7·18
15,919	40·61	14,145	+ 2·24
15,685	37·25	14,991	− 8·08
15,299	34·33	15,452	17·72
14,299	30·97	15,644	25·13
12,689	27·6	15,814	29·62
9,839	24·91	15,914	33·66
5,539	21·88	16,122	38·37
+ 999	19·3	16,221	43·98
− 5,073	16·6		

Table V.—Frequency, 125 per second. Potential at Terminals of Alternator, approximately 62 Volts.

B.	H.	B.	H.
15,936	+41·74	6,776	14·59
16,746	40·95	9,850	12·57
15,119	35·00	12,172	9·20
13,739	30·07	13,615	2·24
11,732	26·48	14,618	− 8·08
9,222	23·11	15,120	19·75
6,462	20·87	15,434	28·61
3,576	19·19	15,622	34·10
+ 1,192	18·18	15,773	38·37
− 3,136	16·16	15,936	41·74

Table VI.—Frequency, 125 per second. Potential at Terminals of Alternator, approximately, 750 volts.

B.	H.	B.	H.
16,698	+45·1	12,862	10·77
16,671	44·65	14,368	1·12
16,565	40·72	15,309	− 9·20
15,311	33·66	15,873	18·85
13,930	30·18	16,099	26·25
11,544	27·15	16,262	30·63
8,411	23·78	16,413	34·33
+ 4,077	21·54	16,564	39·49
− 565	19·30	16,670	43·98
5,396	16·83	16,689	45·10
9,454	14·36		

for B and H are given in Tables V. and VI., which have been obtained from the curves in Figs. 11 and 12 respectively. These curves show the same difference as Fig. 6, but less markedly than in Fig. 5. The L curve was determined twice.

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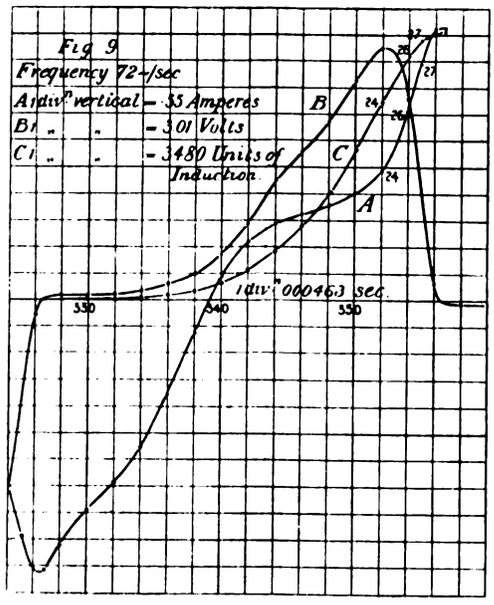

Fig 9.

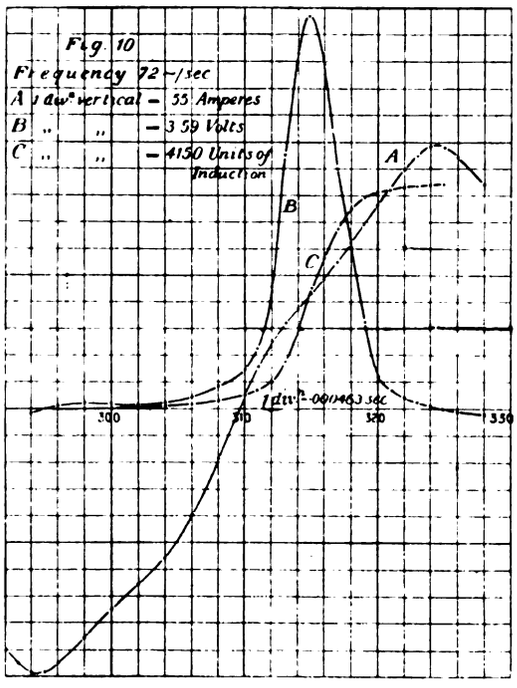

Fig. 10.

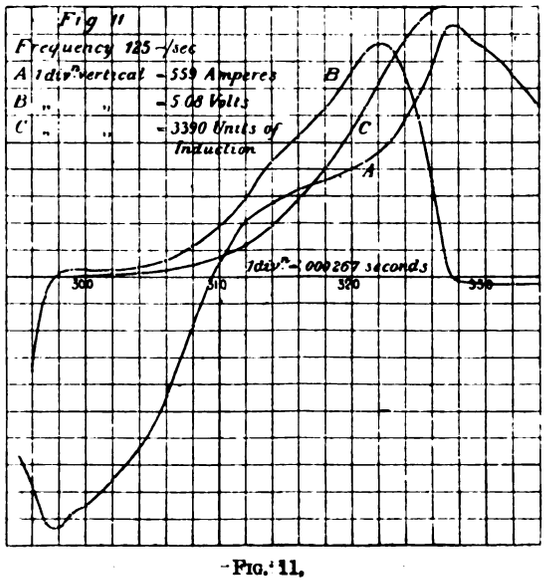

Fig. 11.

Experiments have been made upon chromium steel, supplied by Mr. Hadfield, having the following composition :—0·71 per cent. carbon, 9·18 per cent. chromium, when annealed, and when hardened by raising to low yellow and plunging into cold water. The results show that the same time effect exists in this case, although it was not so marked as in the case of the hard steel.

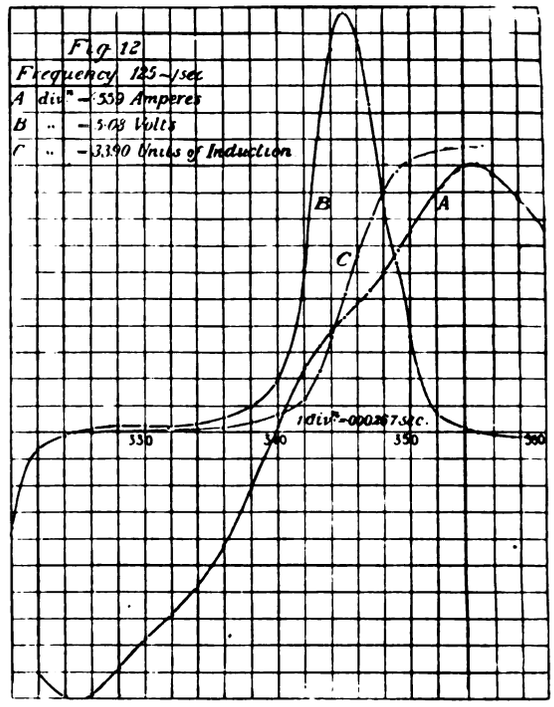

Fig. 12.

We draw the following conclusions from these experiments :—(1.) As Prof. Ewing has already observed, after sudden change of magnetising force, the induction does not at once attain to its full value, but there is a slight increase going on for some seconds. (2.) The small difference between the ballistic curve of magnetisation with complete cycles and the curve determined with a considerable frequency, which has already been observed, is a true time effect, the difference being greater between a frequency of 72 per second and 5 per second than between 5 per second and the ballistic curve.

THE INTERDEPENDENCE OF ABSTRACT SCIENCE AND ENGINEERING.*

BY WILLIAM ANDERSON, F.R.S.

(*Concluded from page 40.*)

It is not often that a genius of the order of James Watt rises in the mechanical world. Up to the time when the University of Glasgow required its model of a Newcomen engine to be repaired, the "fire-engine," as it was most properly called, was being slowly developed without any exact knowledge of the properties of the agent by means of which the heat generated by the combustion of fuel was converted into work, and this in spite of the circumstance that such a master mind as that of Smeaton had been directed to perfecting the new method of utilising the potential energy of fuel, and of applying it to engines of large power, and on an extensive industrial scale.

The bent of Watt's mind was characterised by a love for abstract science, and it was, no doubt, for that reason that he abandoned his father's business and took up the profession of a philosophical instrument maker, in the pursuit of which he naturally came in contact with the meagre knowledge of physical science of the period, and with men eminent in the world of learning and of research.

The lucky chance which presented itself of having to put in order a working model of a Newcomen engine, illustrates in an interesting manner how, in pursuance of his business, he quickly executed the necessary repairs and alterations, and afterwards, at greater leisure, attacked the problem which the failure of the model presented from the theoretical side, but soon found that the then state of knowledge did not afford the means of explaining the

* Abstract of the "James Forrest" Lecture, delivered before the Institution of Civil Engineers, May 4, 1893.

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failure, and compelled him to set about the determination of such elementary data as the specific volume of steam, the latent heat of evaporation and the law of tension of steam under varying temperatures. In the astonishingly short period of two years, and with the rudest and cheapest apparatus, he had furnished himself with the abstract knowledge required for explaining in a definite manner the action of the steam engine, and he had no difficulty, as soon as his theoretical ground was sure, in determining what mechanical arrangements were necessary to realise the conditions imposed by science. From investigations, apparently of an abstract or non-practical character, sprung at once the separate condenser, the closed cylinder and the equilibrium working of a single-acting engine, the steam-jacket, the air-pump, the theory of expansive working, the function of the momentum of the moving parts, and the exact calculations based on first principles by means of which the proportions of engines could be fixed, and the quantities of steam, water, and of fuel calculated. Watt, of course, was a born mechanic, as well as a seeker after physical knowledge. The workshop in his private house near Birmingham, happily preserved to this day as he left it, shows that his mind was ever bent on mechanical contrivances which his own hands were skilful enough to carry out; his valve-gear, the stuffing box, the parallel motion, the governor, are all instances of that happy blending of mechanical skill and of scientific research which must ever mark the qualifications of a great mechanical engineer.

A contrast to Watt's achievements is the singular history of the development of iron and steel bridge building, which necessarily followed the introduction of railways. Watt felt the want of first principles by which to shape his actions, and set about discovering them; but the principles which underlie the determination of stresses in braced structures, such as roofs and frameworks of various kinds, as well as those in solid bars subjected to the action of transverse forces, have long been known; and early in this century Navier made them the subjects of lectures at the Ecole des Ponts et Chaussées, yet engineers in this country seem to have been but dimly aware of them, or, at any rate, to have made little use of the knowledge which was at their disposal. It is difficult, from the published histories of such enterprises as the Conway and Britannia bridges, to arrive at any conclusion as to the extent of knowledge, or rather ignorance, which existed among engineers before these works were commenced. It is probable that some of a specially scientific turn of mind, but who were not in conspicuous practice, had a deeper insight into principles than the men whose great natural genius and knowledge of affairs placed them in prominent positions in the great railway enterprises of the day. It is sufficiently evident, however, from the long series of purely tentative experiments by which the proportions of the Conway and Britannia bridges were determined, as well as from the singular vagaries to be noticed in the smaller bridges of that day, that only the haziest ideas of the disposition of stresses and of the functions of the component members of girders existed. This naturally led to timidity as to the capacity of girders to carry, unaided, the loads it was sought to impose, and induced a preference for masonry or for suspension bridges, with respect to which much wider experience was at command.

In the experimental investigations of the time, the function of the web or vertical member of a girder was completely ignored, for it was looked upon merely as the mean of keeping the top and bottom flanges in their relative positions, while the essential difference in effect of a uniformly-distributed load, or of a rolling-load, as compared with a load concentrated at the centre, on the vertical member of a girder, and even on the flanges, appears to have been overlooked till made evident by the results of experiment; and the grave doubts which arose as to whether the girders of the two great tubular bridges could be made self-supporting are apparent to this day in the preparations made in the piers and abutments for the introduction of auxiliary chains. Yet the principle that a force cannot change its direction unless combined with another force acting in a direction inclined to it was perfectly well-known, and should have led to the discovery that it is only by diagonal stresses in the vertical members that the load resting on a beam can be transmitted to the abutments; that the stresses due to loads concentrated at the centre were very different to those arising, both in the vertical web and in the flanges, from the action due to a load distributed in a given manner along the top or the bottom flanges, and that a rolling load would produce effects peculiar to itself.

The girder with diagonally-braced webs, or the lattice girder, as it is commonly called, appears to have had its origin in Ireland; at any rate, it was in that country that it received its earliest and chief development; but at first, as illustrated by the bridge which used to carry the Dublin and Drogheda Railway over the Grand Canal in Dublin, it was a mere attempt to substitute for plate webs an arrangement of flat bars sloping in opposite directions, placed very close together, and having the oppositely-inclined bars connected at their intersections by countersunk rivets.

Since 1848 the supremacy of theory over rule of thumb has gradually but surely asserted itself, though, at times, the want of common sense and experience in the application of abstract principles, as well, perhaps, as ill-judged efforts to produce cheap structures, has led to disasters quite as serious as those which arose from want of theoretical knowledge; and in this respect the competent and successful engineer will still show himself as the man who, in his work, is careful to make theory and practice walk side by side, the one ever aiding and guiding the other, neither asserting undue supremacy. This course, in its highest development, we may, I think, assert is that adopted by our leading engineers, with the result that this country may claim the honour of such a structure as the Forth Bridge, for the design and construction of which no tentative experiments were needed, though the form and mode of construction were very special, if not absolutely new, and the dimensions, both in span and height, so gigantic that the authors of the design could have derived but little aid from previous experience.

The history of scientific research teems with instances of discoveries which at first seemed to have had no practical value, but which nevertheless have ultimately proved to be of the utmost importance to the engineer. Notwithstanding such experience, and even in these days, there are so-called practical men who are utterly intolerant of either time or money being devoted to investigations which seem incapable of bearing immediate fruit. Many examples might be cited, for instance: the changes of temperature which occur in many chemical reactions were merely noted, at first, as interesting accompaniments to such reactions; but, by degrees, it was perceived that the amount of heat evolved or absorbed in each chemical change was a constant and definite quantity, which was capable of exact measurement, and in process of time the thermal values which characterised a vast number of chemical changes were determined, and are now considered of cardinal importance in many industrial operations, and constitute the science of thermo-chemistry.

At the same time, the total heat of evaporation of water and of other substances was ascertained with great precision, so that it became possible to judge of the efficiency of a boiler, for instance, when the rate of fuel combustion and that at which the water was heated or evaporated were known, by calculating the proportion which the heat imparted to the water bore to that produced by the combustion of any fuel of which the chemical composition had been ascertained, and from which the heat capable of being developed could be calculated by general rules, and thus researches in the chemical and physical laboratories have had the ultimate effect of placing the theory of the steam-engine on a firm basis.

One practical effect of the exact knowledge which every competent engineer now possesses on this subject, or can easily obtain, is that inventors have ceased to squander their time and their means in seeking for impossible high boiler duty, and the public is no more entreated to try contrivances which are to save at least 50 per cent. of the fuel they use, because inventors know that the testing of boilers is now usually carried out by experienced and educated men, who, by very simple and inexpensive trials obtain the data by means of which they can calculate with certainty how much scope for improvements actually exists.

Still more remarkable, perhaps, is the application of thermo-chemistry to the complicated reactions in the blast furnace, and the valuable conclusions arrived at in consequence by such thorough and patient investigators as Sir Isaac Lowthian Bell, Charles Cochrane, and others, who have succeeded in equating the heat-units resulting from the oxidation of fuel to the ultimate thermal results of the decomposition of the ore and fluxes, showing thereby the limits of economy which the ironmaster may hope to reach, and the proportions of the furnaces in which his expectations may be realised.

No less valuable have been the fruits yielded by the discovery of the great law of the Conservation of Energy, and by the recognition of the fact that, though energy cannot be destroyed, it may be made to assume various forms, and may be rendered either dormant or active. The sun's rays, æons of ages ago, during the dense vegetation which charactised the period of the coal measures, expended their energy in tearing asunder the carbon and oxygen of the carbonic acid so sparsely distributed though the atmosphere, and in storing the carbon, thus endowed with potential energy, in the deposits whence we now derive our coal supplies. By suitable arrangements this dormant energy is quickened into that quality of motion which we recognise as heat, and which, setting into sympathetic vibrations the material of the furnace-plates and smoke-flues of boilers, operates on the surrounding water, the molecules of which, under this influence, assume the more extended movements of the highly elastic substance which we know as steam. The products of combustion, on the one hand, are restored to the atmosphere, their remaining store of heat is slowly dissipated, while the carbonic acid gas produced in combustion is again ready to present itself, in the green leaves of plants, to the decomposing action of the sun, and by that means the carbon and the oxygen become once more sources of heat. The steam produced, on the other hand, communicates its molecular motion to external bodies in various heating operations, in

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the visible motion and force of the steam-engine or into the slower dissipation through space or over the earth, whereby it is again condensed to water and returned to its normal condition, while the energy, for the exhibition of which, Carnot has taught us, steam was the mere agent, becomes transformed into masses of water lifted, into air compressed, into electrical currents generated, into mechanical work done, or into the heat developed by friction; but the general tendency is towards dissipation under the form of heat into space, the waste being made good by the stores of heat poured on to our planetary system by the huge and mysterious body which is its centre. Whence this enormous and apparently unfailing supply of heat is derived has been, and still is, the subject of most interesting controversy, the upshot of which seems to be that the heat developed by the shrinkage of our luminary and by the fall on to its surface of meteoric matter is sufficient to keep up the supply, at any rate for many thousand years.

But modern investigators, and, most of all, engineers, are not content with vague statements such as I have just made; they hold with the motto of the ancient Society of Civil Engineers, "Omnia in numero pondere et mensura," and they are, therefore, greatly indebted to Rumford, Carnot, Davy, Mayer and Joule, who not only showed that heat was a "mode of motion," but determined by tedious and delicate experiments its mechanical equivalent.

And what is now the result?

When examining heat-engines or other applications of heat in the arts, the engineer collects the apparently aimless work of half a century, and of many minds, and finds himself able to construct a balance-sheet by which he can show on the Dr. side, to a fraction, the quantity of heat he has received, and on the Cr. page, with astonishing precision, the manner in which that heat has been expended. This method of treatment is not only lucid, but it is self-checking, and it points out how much heat has been uselessly dissipated, and, consequently, in what direction improvements may be made, and it indicated, further, the limits within which it is alone possible to make advances in economy.

One of the loftiest of abstract conceptions relation to the structure of the universe, the product of many acute minds of this century, is the imagining of a substance of infinite tenuity but of immense elasticity, which permeates all space and every substance. It cannot be seen, or felt, or weighed; its composition is unknown; it cannot be pumped out of a closed vessel; itdoes not appear to offer any resistance to the motion of planetary bodies, and its existance is only made manifest by its property of transmitting chemical rays, light, radiant heat, electricity, and probably some more recondite forms of energy, at enormous velocity from the remotest regions of the universe and by means of vibrations the nature of which, the astounding frequency and minute pitch, have been determined by mathematicians. It is pardonable in human beings to disbelieve in the existence of the luminiferous ether, even though the profoundest thinkers and most successful workers of the present day may have all the conviction of Lord Kelvin, who has declared that "it is the only substance that we are confident of in dynamics; the one thing we are sure of is the reality and substantiality of the luminiferous ether!"

But what has the engineer to do with such speculations, and what does it matter to him how light and heat are transmitted from the sun or from the stars, or by what mechanism heat, magnetism and electricity are diffused over the earth? This question is being answered already in our daily practice, and is destined, no doubt, to receive fuller and more convincing response as time rolls on.

The lecturer then alluded to the results of spectroscopic researches, Mendeleeff's theory of the production of petroleum, and recent metallurgical work, after which he continued:—

I think that it is now generally acknowledged that the luminiferous ether is also the medium by which electrical energy is transmitted by some kind of vibratory motion; hence, the ease with which heat or mechanical work is transformed directly into electric currents in the thermopile, or in the frictional electrical machine, and the reasonableness of the great generalisation that we are living on a huge magnet—the poles of which are not far from coinciding with the poles of the earth. To what purpose are the endless observations on the deviation and dip of the magnetic needle which are so assiduously carried on by every civilised nation, and what interest have engineers in the painful labours of those daring explorers who set up their Observatories amidst the endless ice and the darkness of the Polar regions?

Let such a questioner, if there be one, study the construction of the mariners' compass, and especially in the improved form introduced by Lord Kelvin; let him compare the blind groping after correction for the local attraction of the ship with the beatiful and simple theory which has rendered that correction not only easy but readily adapted to changes in the ship's position in the world; he will find that there is not a more striking instance of the profoundest abstract knowledge blended with the power to turn it to practical use than in this and in so many other labours of the distinguished man whom I have named more than once, and whom this Institution is proud to number among its honorary members.

I will not dwell upon the wonderful results of which we are today reaping the benefit, and which have arisen from the application of the most profound scientific knowledge to the problems which arise in the generation, storage and application of electricity, to the transmission of power, to telegraphy, and to lighting; but I would draw your attention to a startling consequence of the undulatory theory in the power which exists of existing influence, by what is termed induction, at great distances. Animated by the conviction that electric energy was transmitted in the same manner and by means of the same all-pervading medium as radiant energy, and that the distance to which its effects would reach should be unlimited, though the appreciation might be a question of the delicacy of instruments, Mr. Preece has succeeded in sending messages by Morse signals across the Bristol Channel between Lavernock and Flatholme, a distance of over three miles. The electromagnetic disturbances were excited by primary alternating currents, having a frequency sufficient to generate a low musical note in a telephone, in a copper-wire 1,237 yards long, erected on poles along the top of the cliff on the mainland. The radiant electromagnetic energy was transformed into currents again in a secondary circuit 610 yards long, laid along the island parallel to the first and at a distance of 3·1 miles; the messages were read off on the island through the instrumentality of the induced currents, and the experimenter was gratified to find that the results obtained on the secondary wire were in complete accordance with the expectation which theory led him to entertain.

Any one who has meditated deeply on the nature of the luminiferous ether and on its universal presence has probably felt that it must also be concerned in the action of the human brain. The mechanisms of the "five gateways of sense" have been worked out by anatomists and physicists, but their researches are incompetent to declare how the impressions sent along the nerves at last reveal themselves as images or perceptions in the mind. Lord Kelvin has discoursed on this matter; he has suggested the existence of a magnetic sense, and has shown that the mind may be influenced independently of the recognised organs of perception. There are, undoubtedly, occult phenomena which can only be accounted for by the supposition that one mind can interact upon another, even as Mr. Preece's parallel wires acted on each other.

I have already alluded to the circumstance that the engineer cannot be satisfied with vague statements or with mere abstact opinions. The very nature of his calling implies action; he has to construct his works must be stable; his machinery must act; his estimates of cost and of the consequences of his operations must come true; and hence he has to make a close alliance with that most facinating and fruitful of the sciences—mathematics. It is not given to many to possess the peculiar aptitude which leads up the highest investigation, but neither has the engineer often need of anything deeper than almost elementary knowledge, especially if he gets into the habit of working out the problems that come before him by the graphic methods which are now so assiduously cultivated, and if he will realise that slovenliness in the matter of calculations commonly leads to disastrous results. Though his attainments may not be high, and though disuse may have made it difficult to wield the power which knowledge, early acquired, once gave him, yet he can always appreciate and put his faith in the great minds which delight in subjecting the theories of physicists to the rigid test of mathematical analysis, and thereby stamping them with the seal of irrefragable feat.

One great quality he must possess, especially in these days when numerous science colleges have rendered high mathematical training of easy access—and that is common sense. There is a tendency among the young and inexperienced to put blind faith in formulæ, forgetting that most of them are based upon premises which are not accurately reproduced in practice, and which, in any case, are frequently unable to take into account collateral disturbances, which only observation and experience can foresee, and common sense provide against.

I have endeavoured to show how the history of abstract science—by which I intend to designate the history of researches entered into for the sole purpose of acquiring knowledge of the operations of Nature and of her laws, without any thought of reward or expectation of pecuniary advantage—has had its reflex in the records of the engineering profession, and how the most recondite investigations, apparently unlikely to have any direct influence on our practice, have, in course of time, become of cardinal importance. I have also ventured to point out how, in these days, the engineer must banish from his mind the idea that anything can be too small or too trifling to deserve his attention. "Nothing is too small for the great man," is, I am told, written over the cottage once occupied by Peter the Great at Saardam. The truth embodied in that legend should ever dwell in our minds; for success, I am persuaded, lies largely in close attention to details.

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You may, perhaps, think that I have endowed abstract science with undue importance, and that I have claimed too wide a domain for the engineer. If this be so, I would turn to the old and faithful servant of this Institution, in whose honour it has been a labour of love to prepare this discourse, and ask him for his verdict.

You can anticipate his answer! Who does not know how jealous he is of the honour and prestige of our Institution? Who is not aware that he will not concede that any branch of physical science is beyond its province? Nor will he yield to any of the younger societies more than the position of tributary powers. He is glad, as we well know, to recognise as our children institutions dealing with special branches of the profession; he is glad to foster them in every way, and rejoices to see them meeting under the eyes of the fathers of the profession, whose portaits adorn these walls: but I am confident that he will declare that you cannot touch anything in natural science which will not, sooner or later, prove of advantage to the members of this Institution, and which the engineer will not, in time, turn to the moral as well as to the material advantage of the human race.

LEGAL INTELLIGENCE.

Woodhouse and Rawson, United (Limited).

Four petitions for the compulsory winding up of this Company, which was in voluntary liquidation, came before Mr. Justice Vaughan Williams on Wednesday.

An application had previously been made to the Court, three petitioners appearing, for a winding-up order under the order of the Court, but as Counsel acting on behalf of creditors objected to a supervision order on the ground that it would prejudice their position, and pressed for a compulsory winding up, the matter was adjourned in order that the creditors so objecting might appear as petitioners. Sir Horace Davey, Q.C., was present on behalf of the liquidator appointed in the voluntary winding-up.

Mr. WHEELER said originally a petition was made by a debenture stockholder, for whom he appeared, for the compulsory winding up of the Company. A question of law arose as to whether his client was really a creditor and had a right to appear, and that question had not yet been settled. The other petitioners agreed to accept a Supervision Order, and he was instructed to say that his client was also, in the circumstances, agreeable to that course. There was opposition to the Supervision Order on the behalf of creditors, and the petition was ordered to stand over in order that it might be ascertained how far a new rule, which had only just come into force, would apply.

Mr. UPJOHN appeared for a creditor, and asked for a Compulsory Order, but Mr. WILKINSON, who appeared for a number of creditors and debenture holders, preferred a Supervision Order, as also did Mr. ARCHIBALD, who appeared for a creditor who had filed a petition against the Company so far back as March last, and who asked that costs should not be allowed on the other petitions.

Sir HORACE DAVEY said the whole question resolved itself into a question of costs. He appeared for Mr. Young, the voluntary liquidator, and notwithstanding the statements made in Mr. Upjohn's petition, he submitted that it was not Mr. Young's intention to take any part in the discussion as to whether there should be a voluntary or a compulsory winding up. There was a scheme for the reconstruction of the Company, but Mr. Young said nothing as to the probability of that scheme meeting with acceptance of the shareholders and creditors. In an affidavit made by Mr. Leslie, the Receiver appointed in a debenture-holder's action, he stated that he valued the assets of the Company at about 50 per cent. of the debenture stock; his valuation was something like £117,000, and the amount of debenture stock was about £200,000, so that if that valuation was correct, there was only enough to pay 10s. in the £ to the debenture-holders, who had the first charge. There were claims against the Directors, but the highest estimate he had heard as to these claims was £87,000, so that, assuming the full amount was recovered, there would still be insufficient to meet the claims claims of the debenture-holders, and in that case he was afraid Mr. Upjohn's client would have to be content with the knowledge that he had discharged what he felt to be a public duty gratuitously, and with the reflection that virtue was its own reward. With regard to costs, there had been five petitions filed, although there were really only four before the Court. If his Lordship thought fit to make a winding-up order, it was an important question in principal, though perhaps an academic one, whether more than the first two petitions were necessary.

His LORDSHIP asked to what extent the reconstruction scheme would be possible under a compulsory winding-up order.

Mr. UPJOHN said there was provision in the Act to allow of a compulsory winding up to be stayed if necessary. Mr. Leslie's estimate of the assets of the Company, seeing that he was acting for the debenture-holders only, was not likely to be an excessive one; was, indeed, much more likely to be too moderate. The actual amount of the debenture stock was £180,000; and, even upon Mr. Leslie's estimate of £117,000, and with the £87,000 which had been stated as the amount claimed from the Directors, there would be an actual surplus for the benefit of the creditors. They hoped, with such means of investigation as his lordship could give them, to increase that.

His LORDSHIP said he was of opinion that he ought to make the compulsory order that was asked for. He proposed to make the order, as he understood he had the right to do, upon all the petitions that were before him; but he did not propose to allow costs on all those petitions. His view of the matter was that if it had not been for the presentation of a fourth petition, the compulsory order which he was now going to make would not have been made at all. He should, therefore, allow costs on the petition of Charles Ebenezer Challis, Mr. Upjohn's client, alone. This was a liquidation in which he was not at all satisfied but that there might be a large surplus after all the claims of the debenture-holders were satisfied. Persons in the position of the Receiver, Mr. Leslie, were extremely apt to underestimate the assets in the interests of the debenture-holders, and it was frequently the case that the debenture-holders included amongst their number persons who, if they were not Directors or officers of the Company, or vendors to the Company, or promoters of the Company, were really connected with those classes, and their interest was that there should be as little public investigation, as well might be. They very naturally pressed their views upon the Receiver, who acted for the debenture-holders, as to the small amount likely to be realised by the assets, and the Receiver, not unnaturally, adopted their views. In this case, the Receiver admittedly had not taken into consideration the large claims which it was said might be made upon the Directors. It was impossible for anyone to judge with any accuracy what the amount of such claims might be, although £87,000 had been mentioned; all it was possible to say was that there were large claims, and they should be taken into consideration when dealing with the question of whether there ought to be an order at the instance of the creditors. The conclusion he had come to was that it was impossible that there could be any certainty even in regard to the probability that there would be no surplus after the debenture-holders were satisfied; on the contrary, on the evidence he was convinced that there probably would be a surplus. Thus, the creditor having clearly a *locus standi*, as there was reasonable prospect of something coming to him under the liquidation, consequent upon a compulsory winding up, the only other question he had to consider was whether the mere fact of the existence of a voluntary liquidation ought to prevent him from making the order for a compulsory winding up, and he thought not, because he was clearly of opinion that, having regard to the nature of the assets, having regard in particular to the large claims against the Directors and others who had been concerned in the management of the Company, it would be a serious prejudice to the creditors if the voluntary liquidation were allowed to proceed. He did not, for a moment, mean to suggest that Mr. Young, the liquidator, would not, on his part, do everything which he ought to do to ascertain what claims the Company had which might be realised; but the real fact of the matter was that Mr. Young, as the voluntary liquidator, had not the means to hand which the Official Receiver had for making the necessary enquiries. In a case like the present, where there were charges made against those concerned in the promotion and management of the Company, charges which might have some foundation in fact and might turn out to be true, it was plain that it was a case for strict inquiry, and under the circumstances it seemed to him that, however anxious Mr. Young might be to perform his duties efficiently, it was impossible that he should be able to perform them with the efficiency that an Official Receiver would be able to do. He therefore made the order for the compulsory winding up.

National Telephone Company (Limited) v. Harston.

In the Sheffield County Court last week an action was brought by the National Telephone Company against Mr. G. Harston, a tradesman, of Glossop-road, Sheffield, for £45, being the rent of a telephone from 1891 to 1893. It appeared that in January, 1889, the defendant entered into an agreement with the Sheffield Telephone Exchange Company for wires to be supplied to his shops and mill at a charge of £7 per wire per annum. In the following August the plaintiff Company purchased the Sheffield Company's exchange business, and took over the defendant's debt. £24. 11s. 4d. was paid into Court, the defendant contending that under his agreement this was all he was liable for, as attached to the agreement was an undertaking that if any reductions were made in the legal rates the defendant should have the benefit of such reduction. In January, 1891, the plaintiff Company reduced their general charges from £10 to £7, and the defendant claimed that, although he was only paying the £7 per cent., he was still entitled to this reduction of £3 per cent. per wire, the plaintiff Company, however, contending that the reduction referred to did not apply to such lessees as the defendant, but only to persons paying over £7. The question, therefore, was to decide whether the plaintiff Company were justified in claiming the full amount, or whether, under the circumstances, the defendant was legally entitled to the abatement claimed.

Judge ELLISON, after hearing the evidence, and remarking that the defendant had paid more into Court than was necessary if his version were the right one, reserved judgment.

Lindsay v. Cowper.

This case, which came before Mr. Justice Lawrance and a Common Jury last week, was one in which Sir Coutts Lindsay sought to recover three quarters' rent in respect of No. 80, Grosvenor-street, held on a long lease at £300 yearly rent by the defendant, a surgeon. One quarter's rent was admitted to be due, and paid into Court; as to the others, it was claimed no rent was due by reason of an interference with the defendant's enjoyment of the premises. It appeared that at the Grosvenor Gallery the London Electric Supply Corporation had carried on their business, and had established their works on the premises abutting on the defendant's tenement at the back. Of these premises the plaintiff was the landlord; and when the defendant made serious complaints of the noise created by the steam engines and the dynamos, an agreement was come to that no rent should be due from the defendant so long as any interference with his enjoyment existed by reason of the machinery of the Corporation.

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Shortly after, in 1890, the engines and the dynamos were removed to Deptford. No further complaint was made of any noise until January, 1892, when complaint of noises coming from the same premises, but of a different character, was made; it was alleged that they continued for six months, and that no rent was due during that period. In answer to this, it was said that, as to part of the noise complained of, a "humming" noise, it proceeded from the "transformers," which had been there throughout the whole period without any complaint since 1890. As to the other part, the "beating" noise, that did not proceed from the premises as to which the agreement had been made, and could not be raised as a defence for the non-payment of rent, while, further, the noise was from a meter, and was of a very harmless kind, much like the sound of a clock.

Mr. Dickens, Q.C., and Mr. Willes Chitty were for the plaintiff; Mr. Winch, Q.C., and Mr. Scrutton for the defendant.

The onus being upon the defendant to establish the existence and the causes of these alleged noises, Mr. Winch, Q.C., opened the case, and examined Mr. Cowper. The defendant said all the nuisance was caused to the back rooms of his house—the kitchen, consulting-room, drawing-room, and his own bed-room. The engines had made "night hideous"; after their removal no further sounds were noticed until the end of 1891, and then two sounds arose which were most objectionable—an intermittent "humming" sound, like a threshing-machine at work next door, and a continuous beating sound. The humming sound abated in May, 1892, and so did the beating sound later on.

Mrs. Cowper, defendant's wife, said the nuisance had driven her from the house, and she had hardly been there at all during the continuance of it. Defendant's daughter and a visitor at their house also described the noises and their unpleasant effect. They made that side of the house uninhabitable.

Evidence was called on the plaintiff's side to show that the only transformers on the premises in question were in the basement, 20ft. below the defendant's basement. There were two there of about two tons weight between February, 1891, and May, 1892; but the heavy transformers of modern construction made less noise than the older and smaller. They did make a humming noise, but not at all a loud noise. Whatever noise they did make had been going on continuously and without any change from February, 1891, until May, 1892, but no complaint whatever was made during 1891 There was no noise that could disturb the defendant.

A meter was produced which was said to be the source of the beating sound complained of, and a current was passed through it; the sound which proceeded was like that of a clock.

After Mr. DICKENS and Mr. WINCH had addressed the jury,

His LORDSHIP said the only question for them was under the agreement. Considering the circumstances and the parties, had there been "any interference" substantially with the defendant's enjoyment? If there had been, the bargain was "no rent." The "interference" must come from the "transformers" in the basement, as the agreement only extended to them.

The jury brought in a verdict for the defendant, for whom judgment was given, with costs.

Loveland v. The Gas Light and Coke Company.

The case was tried in the Lord Mayor's Court in February last, by the Recorder and a special jury, and the plaintiff obtained a verdict, with £40 damages. On Tuesday last week it was sought to set aside the verdict, on the ground that there was no evidence of negligence. The case was tried before Justices Charles and Vaughan Williams. Mr. M'Intyre appeared for the plaintiff; Mr. Bigham, Q.C., and Mr. Morten represented the Company.

Mr. BIGHAM, in opening the case for the appellants, said the question for their Lordships to decide was whether there was any evidence to go to the jury. Most of the facts were admitted, but there was a dispute as to what was the real cause of the explosion. It took place in Great Tower-street. Harp-lane ran north and south, and Great Tower-street east and west. On the right and left of Harp-lane, where it entered Great Tower-street, were two electric-light boxes. These boxes were not air-tight, but were more or less water-tight. On October 14th last the defendant Company's men were working to the east of the box where the accident happened, using picks for the purpose of taking up the concrete, in order to get at some leaky gas-pipes; and at nine o'clock at night there was an explosion of gas, which had in some way gathered in the box. The explosion was of such force that the lid of the box was smashed to pieces, and the pressure of air forced up the lid of the other box, on which the plaintiff was standing. The first point of the other side was that there was a negligence of commission in improperly laying the gas-pipes; and the second, that there was negligence of omission in not finding out the leakage sooner. The third head suggested that the men in using their picks had caused sparks, which had ignited the mixture of gas and air, and thus brought about the explosion. There might be evidence of negligence in the present case if the Gas Company had had opportunities of finding out the escape and had not used reasonable means to do so. The evidence of Joseph Ansell, the housekeeper at 21, Great Tower-street (the City Meters' Office), was that for about a week before October 14th they had noticed a very strong smell of gas in the house. Ansell said he had made a complaint to his superiors; but that had not reached the Gas Company, who had never heard of it until the afternoon of the day when the explosion happened. Another witness named Rayden, a clerk in the same office, said he had noticed the smell of gas for twelve months, and that it was sometimes so bad that he could hardly bear to be in the place. The question was whether there were any means by which the Gas Company could have discovered the leak. They could not go inside houses smelling about for a possible escape of gas. The Company sent round men called leak-detectors, to examine the syphons and water-boxes; but they could not be periodically digging up the streets, in order to look for leaks of which there might be no evidence whatever. Mr. Foulger, in his evidence, said that, in his opinion, the explosion was caused by the gas going up the electric column, and being ignited at the light itself.

Their Lordships then delivered judgment, without calling upon counsel for the plaintiff.

Justice CHARLES said in this case they were invited to say that there was no evidence of negligence on the part of the defendants to go to the jury. It was proved by the evidence of persons resident in, or employed at, No. 21, Great Tower-street, that for a long period prior to October 14th there had been a smell of gas in that house. Two entries made by the defendants themselves as to the state of the main opposite No. 21 had been put in, which disclosed that there were two leaky joints in the main. There could be no doubt, having regard to the evidence, that those were leaky joints of long standing. In that state of things, the defendant Company asked the Recorder to stop the case, on the ground that the plaintiff had not proved negligence on their part. The Recorder very properly declined to stop the case: and thereupon the defendants took upon themselves the onus of showing that the state of things in the main, and the existence of those leaky joints, could not by reasonable care have been known to them. He was of opinion that they had signally failed to prove it. On the contrary, their evidence supplemented to a considerable extent the evidence offered on the part of the plaintiff, for it turned out from the statements of the defendants' witnesses that the Company were in the habit of taking steps to see if their mains were in order. They employed men called leak-detectors and also persons called pumpers. If these persons did their duty they would go to that place weekly; and they would, therefore, have been there within a few days of the time that the accident happened. They were not called as witnesses for the defence, and all the defendants had proved was that no report had been received from any of their leak-detectors with regard to the state of those joints. The evidence called on the part of the defendants proved that the leaks were old ones. The ground had fallen away, and one leak was a very bad one. Looking at that evidence, he was of opinion that the defendants had failed to discharge the onus thrown upon them to show that they had exercised reasonable care. They had not thought fit to produce any evidence from the persons whose duty it was to make periodical inspections. The jury were amply justified in finding that this leak was one which might have been discovered by the Company by the exercise of reasonable care; and the verdict would therefore stand.

Justice WILLIAMS said he was of the same opinion.

Mr. MORTEN said the judgment was one of great importance to the Gas Company, and he therefore asked for leave to appeal.

Justice CHARLES said the Court could not accede to the application.

Birmingham Telegraph Factory (Limited).

At the Birmingham County Court last week, before Judge Chalmers, an application was made for the compulsory winding-up of this Company by Messrs. H. Alabaster, Gatehouse, and Co., London. There were 14 shareholders in the Company, of whom Fowler, Lancaster, and Co. (Limited) were the holders of 400 shares out of 5,000 originally allotted to them as vendors to the Company of property at a price alleged to have been considerably in excess of its value. A meeting of the shareholders was held in February last, when it was resolved to wind up the concern in voluntary liquidation, and Mr. James Rhodes was appointed liquidator. The statement of affairs showed liabilities £7,733, and assets £5,784, but this did not include any liability on account of the shares. Of the 707 shares stated to have been issued by the Company, 307, or thereabouts, had not been paid for. Some of the shareholders and Directors of the Company were also shareholders and Directors of Fowler, Lancaster, and Co. (Limited), and were the holders in their own names of a large number of the shares in the Telegraph Factory, which had not been paid for in cash.

Mr. ALFRED YOUNG, for the petitioners, said that they were creditors of the Factory to the amount of £174 and they were anxious for an investigation by an official liquidator, not only as regarded the doings of the Company, but also in respect of Fowler, Lancaster, and Co. Limited), who were the promoters of the Company, and whose affairs were also in voluntary liquidation. The Telegraph Factory had a capital of £50,000, and the consideration to be paid to the Fowler-Lancaster Company was £5,000, of which £1,000 was to be paid in cash and £4,000 in shares fully-paid up. In the voluntary liquidation of the Factory the Fowler-Lancaster Company claimed to have advanced £6,000 in and about the financing of the Factory Company, for which they had debentures for £3,000 on the assets of the Factory Company, and £3,000 in fully-paid up shares, regarding which latter there had been no payment made whatever. They had been allotted to Lieutentant-General Sir Andrew Clarke, Mr. J. F. Albright, Major Roe, and Messrs. E. W. Lancaster, A. Mason, and G. Fowler.

After some discussion, the JUDGE said that the question turned upon the liability of the holders of the £3,000 of shares, and he suggested that this question of their liability should be raised and decided.

Eventually, the matter was adjourned till next bankruptcy day for Fowler and Lancaster to file further affidavits, and for them to attend the Court for examination. All the books are to be open to the inspection of the petitioners.

Re Fowler, Lancaster and Co.

This was the petition of a creditor for £159 for the winding up of the Company. Mr. Justice Vaughan Williams had on a previous occasion expressed dissatisfaction at the state of the evidence filed on behalf of the respondents, who were the Company and the debenture-holders, and gave them an opportunity of filing further evidence.

Mr. HART on Wednesday stated that the further evidence had been filed, but this had not been cross-examined upon, as it consisted solely of

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the evidence of the liquidator, who got his knowledge from the books and papers of the Company, and of Mr. Fowler, which did not touch upon the matter upon which the creditor based his claim. In respect of £109 of his client's claim, a bill was given and dishonoured. The petition was opposed on two grounds—the first, that nothing was to be gained by a winding up order, because the debentures covered the whole of the assets of the Company, and the second, that there was already a voluntary winding up by which unsecured creditors would not be prejudiced. He asked that his lordship would hold that the receiver had not taken a too sanguine view of the value of the assets he was able to realise, and make a compulsory order.

The hearing was subsequently adjourned to Thursday (yesterday), when it was stated that an arrangement had been arrived at between the counsel, and his lordship acceded to a request that the matter might again stand over for a time.

Electric Arms and Ammunition Syndicate (Limited) v. Lucas.

In the Lord Mayor's Court last week, before the Recorder, the plaintiff Company sued the defendant, a civil engineer at Hammersmith, to recover £42, being calls on shares in the plaintiff Company. The defendant declined to pay on the ground that there had been misrepresentations in the prospectus which was issued by the plaintiffs. The defendant also claimed to have his name erased from the register, and counterclaimed £100, being the amount he had already subscribed on his shares. The syndicate was formed for the purpose of making and vending firearms in which electricity was used as the means of exploding the cartridges and it was claimed for the invention that it could be adapted to all existing kinds of firearms and fowling pieces. The secretary of the Company was called and explained the operations which had been carried on by the Company, including a trial of the weapons at Bisley, and also negociations with the War Office with the object of getting the authorities to adopt the invention. The defendant in his evidence, said he complained that it was not true, as alleged in the prospectus, that negociations were proceeding with foreign governments to induce them to take the weapons. Neither was it true that the invention was perfected, but he had no evidence to produce in support of that view. Upon this the Recorder directed the jury that there was no case for the defendant and a verdict was given for the plaintiffs, with costs on the higher scale.

Electrical Supplies and Fittings Company (Limited).

Mr. Justice Vaughan Williams on Wednesday made an order continuing the voluntary winding-up of this Company under the supervision of the Court.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 5, 1893.

The Effect of the Incandescent Lamp Decision.—The decision of Judge Hallett in favour of the Columbia Incandescent Company of St. Louis against the Edison interests is having a stimulating effect on the electrical business in general, and especially upon the incandescent lamp industry While this decision does not settle the legal fight between the General Electric Company and the outside manufacturers, it certainly has had the effect of breaking the so-called monopoly of that Company. Pending the final hearing, which will consume perhaps a year or two years time, the Columbia Incandescent Lamp Company and a number of other companies can unquestionably pursue the manufacture of incandescent lamps. Already several companies have resumed their business, which had been suspended by the action of the General Electric Company, and incandescent lamps of different makes can now be obtained in the open market, and it seems probable that this state of affairs will continue until the expiration of the Edison patent.

The Opening of the Chicago Exhibition.—On May 1st the Chicago Exhibition was opened by the President of the United States with appropriate ceremonies. While the appointed time does not find the Exhibition in anything like a completed state, there is every prospect of the major part of the exhibits being in good condition within the next two or three weeks. The electrical display, which will, perhaps, be the most attractive feature, both from the standpoint of the general public and the engineer, is further advanced than most of the others, but the Electrical Building is still in in a very unfinished state. The Intra-mural Railway, which was opened to the public last week, marks an important step in electric traction in this country, as it is really the first elevated electrical railway of any pretentions that has been constructed on this continent. The construction of the motors, and their attachment to the cars, the trolley, the feeder and working circuits, are all of particular interest to electrical and street-railway men, but the great 2,000 horse-power generator, in the power station, will probably excite more interest than any other feature. The company constructing the road secured the contract on a bid of 25 per cent. of the gross receipts and a ten cent fare.

CORRESPONDENCE.

COOKING BY ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your attention may have been called to a note in a contemporary interested in gas lighting, criticising Mr. Crompton's lecture at Hove, and making a comparison between the cost of electric heating and the cost of coal. It is stated for purposes of comparison that, taking electricity at 5d. per unit, the price of coal should be £7. 7s. 1d. per ton. I should be glad if you would allow me an opportunity of pointing out to your readers that Mr. Crompton, in his lecture, told his audience that electrical heating, although it appeared costly calculated in the above manner, is not so in reality when the heating has to be applied for short periods of time, and only at the points where it is actually required. A large number of cooking operations come under this head.

The theoretical value in heat units of a ton of coal, and its practical value when burned in the average stove, are two different things. Probably about 50 per cent. of the heat passes up the chimney in the form of products of combustion, and this loss alone would double the price of coal when compared with electricity. For short operations coal is expensive, for a fire is of little use during the first half hour of its existence; and when the fire is done with, a considerable amount of heat is lost in its expiring embers. With electricity the matter is very different, the full heating effect of the current is experienced almost instantaneously, and owing to the fact that there is no combustion, the heated conductor may be enclosed within, or attached to, the apparatus in use. Thus, practically, the whole of the heating effect is utilised, without waste in starting or stopping, for immediately the work is done the current is switched off, and no loss is experienced. From the above facts I consider a fair comparison of electricity with coal would be as two to one. This is for some cooking operations, but not all. Thus, the electric oven completely turns the tables on its opponents. The oven, which is entirely enclosed, is heated, say, to 400 degrees in 15 to 20 minutes at double the cost of gas or coal, but as there are no means for the heated air to escape, the electricity may be entirely turned off when this heat is attained. But for the fact that there must always be some slight loss of heat through the walls of the oven, no more heating would be required. By allowing, however, 25 per cent. of the original current to pass through the oven, the full heat may be maintained, and cooking operations carried on indefinitely. Therefore, if electricity costs twice as much as gas or coal to heat up the oven in the first instance, it only costs half as much to keep it going.

I have tried the experiment of heating up an electric oven to 400°F., and after shutting off all current, taken tests for the next two hours. At the end of that time the temperature was still 250 deg., which is sufficient for many cooking operations originally commenced at a higher temperature. The cooking carried on during the last two hours would not have cost a single cent; in fact, the electric oven acts like a baker's oven, which being heated early in the morning, has to cook afterwards by means of the heat retained.

It is a very simple matter to calculate the cost of carrying out small cooking operations. For instance, taking the usual pressure of 100 volts, a unit will give us 10 amperes for one hour. For heating purposes electricity is supplied by many companies at a lower rate than for lighting, owing, no doubt, to the fact that cooking is mostly carried out during the day. Taking the price at 5d. we get the following:—A large size electric toaster will toast perfectly two rounds of bread in one minute. The toaster takes 7 amperes at 100 volts. If this apparatus is used for one hour it will cost seven-tenths of 5d.;

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i.e., 3½d. At the rapid rate, however, at which the toaster will work, it will probably not be required more than ten minutes at a time, and the current for this would cost one-sixth of 3½d., or a fraction over ½d. Three minutes, however, must be allowed for the toaster to get to its full heat before using, and, therefore, we must add one-twentieth of 3½d. We may very well say that the toaster will work in the most efficient and satisfactory manner for about ten minutes at the cost of less than 1d.

The electric griller will grill four chops or six cutlets in ten or twelve minutes, using 6 amperes. Add to the time taken in actual cooking three minutes to heat up the plate in the first instance, and we find that current will be required for about fifteen minutes at 6 amperes. The cost of this would be about 1½d. It is convenient to remember that at 5d. a unit we are paying ½d. per ampere per hour. To boil a quart of water requires about 3½ amperes for ten minutes, but if we allow a quarter of an hour for this operation, the cost is about ½d. It is quite a question whether the usual spirit stove would be as cheap.

If we add to the above the many great advantages and savings due to the absence of waste heat, smell, smoke, and dirt, the cost of electric heating for many cooking purposes is certainly very little, if at all, in excess of coal. I doubt very much, when all the bye savings are taken into consideration, whether it is dearer at all.

The above figures are taken on the assumption that electricity is supplied at the price of 5d. per unit. It may be obtained, however, at 4d. per unit at the present time in the City for heating purposes, and in other parts of the country it is as low, and at St. Pancras it is charged at 3d. These prices make the comparison still more favourable. The convenience of being able to switch on or off the heating power at will, and to carry on the cooking operations in any part of the kitchen without reference to chimney accommodation will certainly bring electric cooking into favour.

Large numbers of experts have seen the Crompton electric cooking apparatus, and without exception they have declared in favour of its use. The only point which seems to cause them any doubt is the question of safety, but this they soon see is only a "bogey" raised by our opponents. There is absolutely no more danger to life or limb in using electric cooking apparatus than in the use of the ordinary incandescent lamps, for all are worked with the same pressure.

Apologising for the length of this letter.—Yours, &c.,

London, E.C., May 16, 1893. H. J. DOWSING.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1893 Edition of "THE ELECTRICIAN" Electrical Trades Directory and Handbook is NOW READY. This useful book contains over 1,000 pages, and several new and handy features have been added. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

TENDERS INVITED.—The Vestry of St. John, Hampstead, invites tenders for the construction, supply and laying down of plant and mains for the electric-light supply of the parish, in accordance with plans, &c., which can be obtained of Mr. A. H. Preece, of 39, Victoria-street, S.W. Some further particulars are given in our advertisement columns, and the tenders have to be delivered to Mr. Thomas Bridger, Vestry Clerk, by 4 p.m. on Thursday, June 8th.

——— The South Indian Railway Company (Limited) will receive tenders for the supply of general stores, including iron, metals, and telegraph stores until the 30th inst.

——— *Extension of Time.*—Owing to the time originally fixed for sending in tenders for the electric lighting of Clonmel, Ireland, being too short for the preparation of the necessary estimates, it has been decided to extend the time for sending in tenders from May 25th to June 25th next.

TENDERS ACCEPTED.—As was anticipated, the Corporation of Leicester have accepted the tender of the Brush Electrical Engineering Company (Limited) for providing a high-tension electric light installation in a limited area in the centre of the town, the amount of the tender being £27,587.

TENDERS ACCEPTED.—The Town Council of Dewsbury have accepted the following tenders for contracts in connection with their electric lighting scheme, subject to the recommendations of the Lighting and Water Committee, set out on the next page. Messrs. Crompton and Co. (Limited), London, engines, dynamos, accumulator switch boards, &c.; Messrs. Siemens Bros. and Co. (Limited), London, mains (including arc lighting); Messrs. J. and J. Horsfield, Dewsbury, boilers.

——— The Town Council of Hanley have accepted the tender of Mr. Thomas Cass for fitting up with his mechanical coking stoker three boilers at the Council's electricity works for the amount of £270.

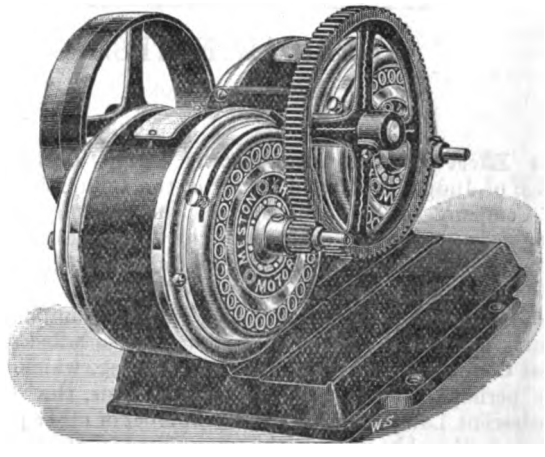
——— The following tenders were sent in for the supply of electric-light fittings for the Horseshoe Tavern, Tottenham Court-road, W.C.:—Messrs. Laing, Wharton, and Down, £354; Messrs. Verity and Co., £351; Messrs. Strode and Co., £301; J. Dodson, £287; Messrs. Vaughan and Brown, £275—the latter tender being accepted.

——— At their last meeting the Bristol Town Council adopted the report of the Electrical Committee, referred to in last week's *Electrician*, recommending the acceptance of tenders for the supply of apparatus at the central and sub-stations.

MESSRS. DRAKE AND GORHAM.—This firm have secured the contract for lighting the new offices at King's Cross for the Great Northern Railway. The installation will consist of between 600 and 700 incandescents. The consulting engineer is Mr. A. H. Preece.

BANKRUPTCY.—On Wednesday, in the Court of Bankruptcy, before Mr. Registrar Giffard, a scheme of arrangement was approved under the failure of C. J. Allport, an electrical engineer, and son of the late Sir James Allport, formerly chairman of the Midland Railway. The statement of affairs shows liabilities to the amount of £14,880, and the scheme provides for payment of the creditors in full.——Creditors of James Collins, lately carrying on business as an electrical engineer, at 80, Church-road, Hove, Sussex, must send in proofs, by the 30th inst., to Mr. R. J. Ward, 7, Pavilion-buildings, Brighton.

NEW SLOW-SPEED ALTERNATING-CURRENT MOTOR.—We give below an illustration of a new alternate-current motor adapted for



small power purposes which is being placed on the market by Messrs. Shippey Brothers (Limited), on behalf of the Emerson Electric Company, and are being supplied in two windings for working on both 50 and 100-volt currents. It will be observed that two motors are mounted on one base and geared to a single countershaft, thus giving twice the power of the single motors. The countershaft is geared to the motor-shaft, which gives the driving-wheel a velocity of 200 to 280 revolutions per minute, the motors running at from 2,000 to 2,500 per minute. We are informed that these motors are self-starting, also self-regulating and reversible, and will automatically synchronise at any speed required, according to the periodicity of the circuit. For working sewing machines, for instance, they can be run to produce from 30 stiches per minute up to 1,500 or over, if required. The armature is made of special laminated iron, but has no winding. The motor has self-oiling bearings, and all the working parts are entirely enclosed.

FIRE.—The premises of Messrs. Lea, Sons, and Co., electrical engineers, Chester-street, Shrewsbury, were seriously damaged by fire on Monday last.

CENTRAL STATION CONTRACTS.—The Scottish House-to-House Electric Supply Company have placed a contract with the Brush Company for the complete equipment of a supply station at Coatbridge on the Mordey-Victoria alternating-current system, the

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generators to be driven by Griffin gas engines and Dowson gas. The Brush Company have also received an order from the Great Northern Railway Company for the supply of arc lamps and accessories for their central station at Holloway.

CHANGE OF ADDRESS.—Messrs. Crosier, Mills, and Co. have removed from 9, Queen-street, to 58, Collingwood-street, Newcastle-on-Tyne.

ELECTRIC LAUNCHES.—Messrs. Drake and Gorham, who inform us they were practically connected with the manufacture and design of the first launches shown on the River Thames, are again devoting their attention to this branch. Two electric launches under the firm's control will shortly be ready for running on the Thames.

MOTORS.—With a view of increasing the day load of central stations, a special section of the thirtieth International Machinery Exhibition at Breslau will be devoted to electric motors. The Exhibition will be open on June 15th, 16th, and 17th. Current will be supplied free to exhibitors. Further particulars may be obtained from Otto Höffer, secretary to the Exhibition, 28, Kreustrasse, Breslau.

BIRMINGHAM.—Before the City Council Mr. Alderman Pollock last week presented the report of the Gas Committee, and deplored the fact that a considerable diminution in the receipts had resulted from the past year's working. No doubt the Committee could have made up for the decrease by raising the price of gas 2d. per 1,000 cubic feet, but they did not wish to adopt that course, as such action would have stimulated the use of the electric light in offices and warehouses, and also in the yards and large works of the district. He anticipated a speedy improvement and an increased consumption of "the cheerful, bright, warmth-giving gas!"

CLONMEL (IRELAND).—Active steps are being taken by the Municipality for obtaining a Provisional Order to light the borough by electricity.

DEWSBURY.—On the 25th ult., Mr. W. H. Preece and Mr. A. H. Preece, attended before the Town Council with a report on the tenders for the central station plant, and at the same meeting a deputation was appointed to wait upon Mr. M. Oldroyd, M.P., to induce him to obtain the electric light for the Spinkwell Mills from the Corporation instead of establishing an isolated plant. On May 2nd Mr. Oldroyd informed the deputation that it was impossible for the mills to be supplied with current from the Corporation's mains, as the installation which his firm were putting in had advanced to near completion, but that in the event of future extension the matter would be considered. With regard to the lighting tenders the Lighting and Water Committee recommended:—(1.) That the provision for lighting with arc lamps the public streets in the compulsory area should be dispensed with, except in so far as the laying down of the necessary tubes for the mains at some future time; this was estimated to save in first cost £2,500. (2.) That the system of electric lighting be a continuous-current low-tension system. (3.) That the engines to be employed be Willans' high-speed direct-acting engines. (4.) That, subject to settlement of details of price between Mr. Preece and the contractors, and to further consideration as to the employment, or otherwise, of batteries or accumulators, and other small matters of detail, the list of tenders as set out on page 78 be accepted. It was also decided to obtain the sanction of the Local Government Board for the borrowing of £25,000 for electric-lighting purposes. It was resolved to approve the plans for the central station. The recommendations of the Committee were adopted by the Council.

EDINBURGH.—The large installation of the electric light at the Caledonian Railway Station was switched on last week, and proved highly satisfactory. In all, 50 arc lamps and about 1,000 incandescents are included in the work, which has been supplied by the Brush Company. The work has been carried out by the Caledonian Company's staff, under the direction of Mr. A. S. Dunn. ——On Tuesday, the Town Council discussed a motion by Bailie Walcot disapproving the decision of a previous meeting of the Council, when it was agreed to retain in the hands of the Corporation the electric lighting of the compulsory area. The Lord Provost, in moving the adoption of the minutes of the previous meeting, pointed out that by passing the amendment they would be deviating from the policy observed by all the large towns in the kingdom. The minutes were subsequently adopted.

GALASHIELS.—The Town Council have resolved not to oppose the application for a Provisional Order by the Company which is to be formed for introducing the electric light for private consumption into Galashiels.

HASTINGS.—The Public Lighting Committee have recommended the installation of the electric light in the Town Hall and Brassey Institute at the total estimated cost of £105. Notice was also given to the local gas company that gas lighting would be discontinued between the Fish Market and the West Marina from October 1st next.

HICKLETON.—The Hickleton Main Colliery Company are sinking a new shaft, and Messrs. Tasker, of Sheffield, have supplied a considerable installation of the electric light, which is ultimately to be in general use in the mine.

HOVE.—A discussion took place at the last meeting of the Commissioners on the subject of the electric lighting of the Town Hall and offices. It appears that 15 tenders and schemes were received in answer to the Commissioners' advertisements, and the tenders of Messrs. Crompton and Co. (Limited), and Messrs. Strode and Co. were recommended by the expert whom the Lighting Committee consulted. The tenders were marked A and B, and amounted to £638 and £725. 6s. respectively from Messrs. Crompton and Co. (Limited), and £905. 3s. 6d. and £454. 17s. 3d. from Messrs. Strode and Co., showing the small difference of £2. 13s. 3d. in the totals of the two tenders. After some discussion the proposal of the Committee to apply to the Local Government Board for sanction to borrow the necessary money was approved. A report of the Electric Light Committee, which also came under discussion at the same meeting, states that over five miles of streets have been opened for electric-light mains, leaving about two miles yet to be completed in the compulsory area, and outside this area a further two miles have been completed.

KILLIN (N.B.).—The proposal for lighting the town by the electric light, and utilising the water power which is available, is receiving considerable support.

LLANGOLLEN.—At the last meeting of the Local Board Mr. J. P Davies explained to the members the system of electric lighting which is proposed for the town, and moved that steps be taken to carry out the scheme. The matter was referred to a Committee.

MANCHESTER.—At the last meeting of the City Council the estimates for lighting the public free libraries by the electric light were passed, the opinion being expressed that the light would be an advantage to the readers, and would not be extravagant in cost, when the pernicious results of the gas lighting upon the bindings of the books were taken consideration.

NEWPORT (MON.).—In reference to the report of Prof. Robinson and his electric lighting scheme, the Brush Company have offered to submit, free of charge, a scheme and tender adapting their system to the requirements of the town; and the Lighting Committee of the Town Council have accepted this, on condition that the Corporation is not committed to any expense in the matter.

NEW SOUTH WALES.—The cost of the plant for the production of the electric light used at the General Post Office at Sydney, including that connected with the external lighting, was for 1892, £2,543. 16s. 5d.

PRESENTATION.—Mr. J. D. Miller, M.I.E.E., who has been appointed from the Dundee district of the National Telephone Company to Edinburgh, was presented with a handsome timepiece and vase, as a token of esteem, by the members of the Dundee staff. The presentation was made by Mr. Gilmour, the Company's representative in Aberdeen.

ST. PANCRAS.—A report has been received by the Vestry from the Joint Committee appointed to consider the question of combining the destruction of refuse with the production of electricity, and, without recommending the Vestry at the present stage to commit themselves to all the details in the engineer's report, the Committee expressed their approval that the principle should be adopted and that steps should be at once taken for carrying out the scheme.

SHANGHAI.—The New Shanghai Electric Company have undertaken to light the new Central Police Station by electricity at 6d. per unit, with a small addition for transformer rent charge.

SHREWSBURY.—The County Council have been notified of the intention of the local Gas Company to increase the charge for gas for street lamps by 4s. per annum. At the last meeting it was suggested that steps be taken to light the town by electricity, and the Council approved that the matter should be taken into consideration.

SOUTHAMPTON.—The Local Government Board have given their sanction for the borrowing of £400 for the lighting of the free library by electricity.

WEST CALDER.—The Local Committee has laid before the West Calder Co-operative Society a proposal by which they agree to incur the expense of working arc lamps throughout the streets, if the Society will supply the electric current free of charge from their installation. The Society have agreed to this.

WEST HAM.—The Librarian has presented a report to the Town Council of West Ham, in which reference is made to the methods of lighting the principal public libraries throughout the country. He strongly advises the use of the electric light, and if the decision of the Council is favourable to this proposal, that steps should be at once taken to put the work in hand, before the plastering and decorating work is complete.

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PATENT RECORD

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

May 4, 1893.

8,925. H. L. LECONTE and L. A. MEYER. London. Improved electrical time transmitter and alarm.

8,952. F. W. ELLERMANN. London. Improvements in electric accumulators.*

8,958. G. G. B. RIGOLA. London. Improved apparatus for applying electricity to the body.

May 5, 1893.

8,969. G. J. SOMERVILLE and R. MCLEAN. Manchester. Improvements in switching arrangements at telephone exchanges and subscribers' instruments.

May 6, 1893.

9,090. W. S. BOULT and C. R. BOULT. London. Improvements in or relating to the parallel working of alternating-current generators specially applicable in connection with gas and similar engines.

9,092. W. S. BOULT and C. R. BOULT. London. Improvements or in relating to the "capping" of electric incandescent or glow lamps.

9 126. J. JEYES. Plumstead. An electric arc lamp, improved method for maintaining a uniform arc.

May 8, 1893.

9,136. E. J. PATERSON and J. FOXCROFT. Dalston. An improved clutching device for use in electric arc lamps.

9,149. C. A. RANDALL. London. Improvements in telephony.

9,171. H. DE PHILLIPS. Dover. Improvements in electrically-illuminated gunsights for use at night.

9,184. E. C. DE SEGUNDO. London. An improvement in arc electric lamps.

9,204. H. E. HARRISON. London. Improvements in electrical measuring and recording instruments.

May 9, 1893.

9,262. O. ERICSSON. Birmingham. Electric meters.

9,281. R. H. GOULD. London. New apparatus for counting telephonic messages.

9,295. T. CRANEY. London. An improved electrolytic apparatus.*

9,296. T. CRANEY. London. Improvements in apparatus for the electrolysis of salt.*

9,297. T. CRANEY. London. An improved electrolytic apparatus.*

9,302. W. Q. PREWITT. London. Improvements in contacts for underground electric railways.*

9,304. A. J. BOULT. London. Improvements in electric lamps. (J. Waring, United States.)*

9,308. F. VOGEL. London. Improvements in machines for equalising electrical currents without a current inverter.

MAY 10, 1893.

9,358. G. BINSWANGER. London. Improvements in connections for electric lighting and like purposes.*

9,380. R. HADDAN. London. Improvements relating to automatic breaking of current circuit for electric lamps or other devices. (A. Reisinger, Germany).

9,397. C. R. GARRARD and T. W. BLUMFIELD. London. Improved means for taking or transmitting power from electro-motors.

May 11, 1893.

9,473. G. RUSSELL. London. An improved electrical device for curative purposes.

9,478. H. H. LAKE. London. Improvements in insulators for electric wires. (Hartmann and Braun, Germany).

9,479. R. CHAVARRIA-CONTARDO. London. Improvements in, or connected with turnstiles, and electric counters connected therewith.*

May 12, 1893.

9,486. W. GREENHALGH and S. W. CUTTRISS. Leeds. Improvements in stands for electro-motors for dental and other purposes.

9,529. J. A. MCMULLEN. London. Improvements in or relating to the distribution of electricity for electric lighting or other purposes.

9,552. F. PETZOLD. London. Improvements in or relating to microphones and telephones.

9,557. H. N. PRENTICE. London. Improvements in dynamo electric machines and electric motors.

May 13, 1893.

9,627, H. FARADAY. London. Improved means for supporting porcelain or other imitation candles on electric-light fittings.

9,630. L. DE KOSTECKI and A. A. PICAL. London. Improvements in or relating to electric arc lamps.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1892.

9,515. PERRY and HOLLAND. Ammeters and voltmeters.

9,678. EDGAR and MUNRO. Electricity distribution.

10,823. BULLER. Telegraphic, &c., insulators.

11,525. HARDINGHAM (Felten and Guilleaume). Electric cables.

16,316. LAWRENCE. Rheostats.

17,462. MEIR. Earthenware electric switches, &c.

23,113. VON DOLIVO-DOBROWOLSKI and others. Electric alternating currents.

1893.

1,840. DEAN. Electric railway signalling.

2,674. HOLCOMBE. Electric switches and door locks.

4,356. THOMPSON (Coffin). Welding metals electrically.

4,746. IMRAY (Bottom). Incandescent electric lamps.

5,340. LUNDELL and JOHNSON. Electric motors.

6,036. JACKSON. Insulated conductors.

BOOKS RECEIVED.

"Electric Lighting and Power Distribution," part 2, by W. Perren Maycock. (London: Whittaker and Co.) Price 2s. 6d.

"Recent Researches on Electricity and Magnetism," intended as a sequel to Prof. Clerk Maxwell's "Treatise on Electricity and Magnetism." By Prof. J. J. Thomson, F.R.S. (Oxford: Clarendon Press.) 600 pp., demy 8vo.

"Journal of the Institution of Electrical Engineers." Vol. XXII., No. 105. Edited by F. H. Webb. (London: E. and F. N. Spon.)

"Proceedings of the Royal Society." Vol. LIII. No. 321. (London: Harrison and Sons.)

"Journal of the Franklin Institute." May, 1893. (Philadelphia: Franklin Institute.)

"Proceedings of the Academy of Natural Sciences of Philadelphia." October-December, 1892. (Philadelphia: The Academy.)

Proceedings of the Royal Society of Edinburgh, Session 1891-92. (Edinburgh: Neill and Co.)

"Guide to Electric Lighting," by S. Bottone. (London: Whittaker and Co.) Second edition. Price 1s.

COMPANIES' MEETINGS AND REPORTS.

West India and Panama Telegraph Company (Limited).

The thirty-second ordinary general meeting of this Company was held on Tuesday last at Winchester House, Old Broad-street, E.C., Mr. C. W. Earle presiding.

The SECRETARY (Mr. R. T. Brown) read the notice convening the meeting and the minutes of the previous meeting, the latter being signed by the Chairman as correctly entered.

The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen—It is almost exactly a year ago that it was my duty to refer to the first death which had occurred on the Board of this Company that was elected to manage its affairs in the year 1874, and now I have again the same painful duty to perform in reporting that another venerable member of our Board has been taken away. Sir James Anderson, whose death we mourn to-day, was so well known and so highly appreciated in the telegraphic world generally that it is unnecessary for me to say very much about him. Many of you know he first came into connection with telegraphic business by successfully laying the 1866 American cable, which made the first telegraphic communication between the old and new world. He was knighted by Her Majesty after the service of that important operation, and left the sea, on which he had spent the earlier years of his life, and took a very leading part in the establishment, management, and administration of the great submarine lines which followed upon the successful laying of the American cable. He was Managing Director of the Eastern Telegraph Company, Chairman of the Brazilian Submarine Company, and, in fact, there is hardly an important submarine telegraph enterprise with which Sir James was not connected. The great experience that he gained in the working of these different lines was of very great value to us on this Board. Besides these advantages, we had the satisfaction of being associated with a most liberal-minded, kind, and thoroughly honest gentleman. I should be very much surprised to hear that Sir James Anderson ever made a single enemy during his whole career. He was so kind and considerate to all that, in fact, I should not be disposed to think very well of the man who said that he was Sir James Anderson's enemy. I am sure that the various staffs that he controlled will feel his loss as much as the Boards of which he was so distinguished a member.

The principal feature of the accounts which we present to-day is that there is an increased revenue of £2,217, and a decreased expenditure of £141. This small decrease in expenditure does not quite measure the real decrease, because in the accounts of the corresponding period of last year we had charged a sum of £2,119 to the reserve fund, as

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some repairs were made which were really of so extensive a character as to constitute renewals in some portions of our system. Therefore, we may look on our accounts as showing an improvement of £4,000 over the corresponding period of the previous year. The items which make up the difference are to be found in abstract "C" of the accounts, which relates to the repairs of the system. This half-year our repairing bill is about £3,000 less than it was in the corresponding period of 1891. We used in the maintenance of our system 37 knots of cable, as against 78 knots; therein being the difference in the expenditure on that part of the business. In order to keep our reserve up to what we think it ought to be, we have decided to put £1,500 to that fund. Abstracts "A" and "B," I think, afford no subject for particular remark. There are slight variations in the items, sometimes increases and sometimes decreases, as compared with last year's accounts, and these are dependent mainly on the fluctuations of the staff and so on, and are not material. The traffic receipts show an increase of £2,065, but it must be borne in mind that these compare with a decrease of £7,350, which we had to report in the corresponding half of last year, owing to the reduced tariffs that we were compelled to initiate at that time. The increase this half-year may be attributed entirely to the improved conditions of the West India trade. Sugar, cocoa, and other staple articles in which the West Indies deal, have risen very much in value, and this has given a filip to telegraph business. Comparing this account to-day, and its increase of £2,065, as against a decrease of £7,350 last half-year, we get to the figure £5,285, compared with what we were making in the corresponding half of the previous year, the one in which we made the reduced tariffs, and that is, I presume, the measure of the loss. Yet we are told that if we reduced tariffs we should have a very much better business. Reductions have been tried in all parts of the world, and I think I am right in saying that wherever they have been tried there has been a considerable loss; and especially in countries like the West Indies, where the bulk of the inhabitants are not of the Anglo-Saxon or European race, the traffic has never increased in proportion to the decreased tariffs. It is rather disheartening to find that our subsidies have been reduced. The Colony of Trinidad, which gave us, for a term of ten years, £6,000 a year, has reduced the amount to £3,000 for one year. The Colony of St. Lucia has also reduced its subsidy from £800 to £500. That seems rather rough after we have given them such considerable reductions in the tariffs. In 1874, when we took office, the subsidy payable by Trinidad was £2,500 a year; but when the term of the subsidy, which had been guaranteed, lapsed, we made strong representations to the Colony of the necessity of allowing something more, and they liberally increased it to £6,000, or more than double the amount. The Colony is, perhaps, not very flourishing financially just now, and it has knocked off one-half of what it used to pay us. In the case of St. Lucia there was a subsidy of £500. We represented to the authorities there, as we did to Trinidad, that we wanted something more, and they increased the amount to £800; and now they have reverted to the original position. This is somewhat disappointing, but it is a matter over which we have no control. One of our ships was recently brought home for the purpose of having a new boiler put in, and that has been very successfully carried out. I may mention that our colleague, Mr. Holmes, had superintendence of the vessel while she was here, and was every day down at the docks, and the work done under his superintendence was admirably performed. Of course, we had a competent engineer to examine the boiler and see it put right, while Mr. Holmes conducted the other business. Gentlemen, that is about as much as I have to say to you to-day. But I shall be very glad to answer any questions which you may choose to put to me. I now move the following resolution:—

"Resolved, that the Directors' report and accounts to December 31, 1892, submitted to this meeting, be and the same are hereby received and adopted, and that, as recommended by the Board, dividends of 6s. per share on the first preference shares, of 6s. on the second preference shares, and of 6d. per share on the ordinary shares (the last free of income-tax) be and the same are hereby declared."

Mr. H. WEAVER seconded the resolution.

Mr. STANSFIELD said that it must be very gratifying to the Directors that they had received the unwavering support of the shareholders for so many years, during which they had had so many difficulties to contend with. What he rose particularly to ask was, what were they to regard as the maximum of the reserve fund.

Mr. BACON said that the only thing that struck him in reference to the working of the Company was the account under abstract "C." He noticed that their ships had been occupied but a very short time during the year, and he wished to ask the Board whether for the work required to be done one vessel would not be sufficient. It seemed to him that it would. If that were so, the shareholders would stand a better chance of an increased dividend. Their ordinary expenses, however, did not seem to be at all extravagant.

Mr. LUCK said that, as one of the ordinary long-suffering shareholders, a dividend of 6d. per share was not a large sum, especially as in his case he paid the full £5 per share for his holding, and the time had arrived when they should receive some consideration by a rigid economy.

Mr. GRIFFITH said that he was sure they all regretted the death of Sir James Anderson, who was undoubtedly a tower of strength in the telegraphic world, and it was unfortunate at this particular time that they should have lost a gentleman in whose experience and skill not only the shareholders but the public at large had so much confidence. As auditor of the Globe Company he had had to transact business with Sir James, and he could endorse everything which the Chairman had said with regard to the urbanity and skill of the deceased. He rather agreed with the remark of the previous speaker, that they ought to consider whether they could not effect greater economies, and especially in connection with the ships. He had been at the meeting of the Western and Brazilian the other day, and it was decided by that Company that one ship would effect all the repairs which would be required. If that Company could hold out such a hope to the shareholders, he trusted that similar encouragement might be afforded in the case of this Company. Although it was important that they should not adopt a cheese-paring policy, it was equally important that they should effect economies in the direction indicated. He also would suggest that they should put by £600 to the reserve fund by way of ship insurance. There was no reason why, if they insured their cables, they should not insure the ships. He did not see why they could not cut down the petty expenditure of £4,900 a year under abstract "C" by having only one vessel.

A SHAREHOLDER asked whether there were any other West India Governments that were likely to reduce their subsidies.

The CHAIRMAN said that they had no intimation of it at the present. With regard to the reserve fund they must be aware that it was accumulated for the purpose of renewing the cables when they became inoperative through old age, and as they had got 4,600 miles of cable, he did not think that with a reserve fund of £140,000, or £150,000, they should stop making contributions to it. As the Company went on, they must provide against depreciation, and he could not hold out any hopes of these contributions to the reserve fund being stopped. They did not amount to very much. Last year they took £2,000 from the reserve fund. The question raised as to the ships occupied the minds of the Directors constantly. They could not take the number of days that the ships were employed as an argument that the Company could do with one vessel, because very often both ships were at sea simultaneously—particularly in the West Indies where they were exposed to hurricanes, and where their ships had to be employed at the same time; and if the traffic were interfered with the Colonies stopped their subsidies. The shareholders, however, might depend upon it that the Directors would do their best to do away with one ship. They had ordered one of them home to be ready for emergencies, but he thought that they would not send it out immediately to the West Indies, in which case they would reduce the expenses considerably. They might depend upon it that the Directors were looking after the expenditure as closely as they could. He might remind Mr. Griffith that they did lose one ship and got fully paid for it out of the insurance.

The resolution was then carried.

On the motion of the CHAIRMAN, seconded by Mr. HOLMES, Mr. William Andrews, the retiring Director, was unanimously re-elected.

Mr. ANDREWS having briefly expressed his acknowledgment,

Mr. JOHN NEWTON proposed the re-appointment of the auditor of the Company, Mr. John G. Griffiths, F.C.A.

Mr. STANSFIELD seconded the motion.

Mr. GRIFFITH, while supporting the motion, gave it as his opinion that in these times when the public mind is shaken in regard to the soundness of public companies, it might be better to have two auditors instead of one. This suggestion, however, met with little approval, and the motion was carried.

An extraordinary general meeting was afterwards held for the purpose of considering, and, if thought fit, of passing a resolution to alter the minimum number of Directors of which the Board shall consist, in accordance with the Articles of Association.

The CHAIRMAN explained that on the death of Sir James Anderson it was found that they had not the minimum number of Directors prescribed by their Articles, and in order to save the Company the expense of having another member of the Board, they proposed to alter those Articles so as to avoid the necessity of electing another gentleman in the place of Sir James Anderson. It was purely a matter of economy, because the other members of the Directorate did not intend to appropriate the fees appertaining to the vacant seat. He concluded by moving the following resolution:—

"Resolved, that until a general meeting shall otherwise determine, the Board shall consist of any number, not less than four and not exceeding twelve Directors, and article 18 of the Company's Articles of Association shall be read and construed accordingly."

Mr. ANDREWS seconded the motion.

Mr. NEWTON said that he quite approved of the decision of the Board, especially in view of the fact that they were not to divide the fees amongst themselves.

Mr. GRIFFITH said that he could not support his friend, Mr. Newton, in this view, inasmuch as their business was becoming more complex, and it required all the ability they could command.

The motion was carried, there being only three dissentients.

Mr. NEWTON proposed a vote of thanks to the Chairman and the other Directors.

The motion, which was seconded by Mr. BACON, was cordially carried, and

The CHAIRMAN having expressed his thanks, the proceedings came to an end.

London Electric Supply Corporation (Limited).

The sixth ordinary general meeting of the shareholders of this Company was held at the offices on Wednesday, under the presidency of Mr. James Staats Forbes.

The SECRETARY and ACCOUNTANT (Mr. R. Stewart Bain) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, for the purpose of economy we decided to use our own Board-room for this meeting, but were rather alarmed that the space might prove insufficient. I am rather sorry to see that the space seems to be superfluous—a fact, however, from which I must assume that the report which the Directors have sent out has satisfied the minds of absent friends. We have insisted, during the last two or

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three years, upon the engineer and the scientific gentlemen upon whom really, in the long run, the success of this and other similar companies must depend, pledging themselves from year to year as to the progress of the undertaking, not so much as a commerical undertaking as a scientific undertaking, to be some day or other capable of returning some adequate interest upon the capital expended on it. You know, I am afraid too well—we do on this side of the table—that our misfortunes have entirely rested upon the want of knowledge, which was pretty universal, as to this electrical possibility. You know the disasters we have had upon one or two occasions causing our whole business to be paralysed—stopped—for considerable periods, and how that affected the public mind naturally, because in this matter, as in every other thing, people will only attach themselves, for their comfort, convenience, or interest, to things that have been proved can be relied upon. We were in a very unfortunate position. We thought—every one thought—that this thing was started on a highly scientific and highly economic principle, and, of course, if it had acted perfectly, it would have been. It is owing to the very fact that the principle, however good it is, has more or less broken down in practice that we are in this position. Had it been accomodating enough to have broken down in such a manner as to have caused us to have been utterly hopeless of pulling it through, we must have put up with it, and have been content with the position; but it does undoubtedly contain within itself the possibility of being improved upon to the original idea. I am rather laying the ground now for what I shall have to administer to-day—the necessity of patience. In order that you may in a few figures realise the result of the irregularities and breakdowns that have from time to time affected us, I may tell you that we are now in this position. The fire at the Grosvenor occurred in November, 1890. At that time we had 38,272 lights connected, but that immediately dropped to 9,000, and these very speedily ceased altogether. We, therefore, had to begin business again, and I find that at the date of May, 1891, we had worked our way back to 23,000 lights. In 1892—during the year intervening, we had had some further troubles and interruptions, not of three or four months, but of only about as many days, with consequences almost as bad at the moment, for they shocked the public—we crept up from 1892 to 1893 to 55,900 lights. The result of that has been that all the various items involved in getting to the lamp have been slowly, with a great deal of difficulty, but with some degree of certainty, overcome; and the thing now really looks as if it were something like an efficient machine. Of course, if anything like the same progress is made in the two future years as we have had in the two past years, we shall be out of our trouble. One of the things to be borne in mind in this matter is that the working expenses are made up of two kinds of items. One item is, as it were, permanent, and has little or nothing to do with the production of current—that is to say, the quantity or the distribution of current—and which diminishes, therefore, exactly in the proportion that the consumption of current or the number of lamps lighted increases. The other item is what may be called the item connected immediately with consumption. Current is produced by coal chiefly, and there is a direct relation, after a certain number of thousands of units are got, between the cost of the unit up to any number of thousands or millions. That does not affect the fixed charges. The man working the machine costs you the same whether he is producing one million of units or five hundred thousand, and that goes through the maintenance of mains, the supervision, and other things which form a considerable percentage to the total outlay. Coming to the total outlay, the position is not at all satisfactorily relatively to the result; but the question is: Because the result has been disadvantageous owing to causes—however unfortunate, pretty intelligible—are we to throw up the sponge and retire from the business? That is not the temper of your advisers; nor do I think it will be yours when you see that, although the return for the year is not one upon which we can very much congratulate ourselves, still, it does present in itself the element of future hope, and, as far as patience goes, rational belief that the multiplication of customers will go on, and with the multiplication of customers the receipts will increase, whereas, for a large proportion of them, the expenses will remain stationary. This is the very unfortunate state of things—that our receipts in 1891 were £28,684, and that with two years of effort they should now be only £24,281, the expenses in both these years being almost exactly the same—£28,704 against £28,196. The intermediate year, which was a disastrous one for the reason I have told you—the serious breaks—showed even a worse result. Therefore, the point which I would advise shareholders upon, either those present or those who are obliged to depend upon printed matter for their information, is to study carefully these engineers' reports, because Directors of a commercial undertaking are not scientists usually, nor can they control the elements. They can exercise a certain amount of judgment and control, and they can exercise the most difficult and most precious of all gifts—discrimination—as to the value of opinions upon which they depend; and in matters of old history or old experience, it is not difficult at all to come easily to that conclusion; but in this electrical business it wants a very clever fellow indeed to discover whether the scientists are right or wrong till he himself has acquired some experience in the application of the scientific principle. During the past year we have had a good deal of work to get through; we started with something of a too magnificent idea. It was thought that the multiplication of power would be a great commercial power, and so it would be if all that power could always be fully occupied, but the gentlemen who were led away with that idea—the engineers and others—seemed to have forgotten that electric lighting begins with a low demand, culminates at a certain stage with a heavier demand, and then subsides into a low one; and if you start with machinery of one uniform type, calculated to do the maximum at the moment of highest demand, it is obvious that you must be working at great loss in the earlier and later stages. Therefore, what appears now to be the practical conclusion of a good many people is that it would have been wiser to have had a smaller unit. Instead of having two 625 H.P. dynamos and two 1,250 H.P. dynamos, to have started with two of 500 H.P., or some other more modest form of unit, would have been wiser. However, there it is, and we must make the best of the position. During the year we have spent a little money in starting a new unit of 300 H.P. We have one at work and one in course of construction, and it looks very much like having to abandon—for the present at all events, and perhaps for a long time to come—any idea of working with implements of such enormous cost, and so exceptional as 5,000-H.P. dynamos. You know that our plant consists, as I said, of two 625-H.P. dynamos and two of 1,250-H.P. These are all at work, but the 1,250 ones are not without drawbacks. First of all, as I think I had occasion to say before, if it so happened that you had to start with a 1,250-H.P. dynamo, it would be like cracking a nut with a steam hammer. A 300-H.P. dynamo does the work quite as well at starting, and the consumption of fuel is infinitely less. It all comes to this, apparently, therefore—whether these remodellings and experimental improvements are in the right direction. We believe that they are. We believe we have reason to adopt the report of the engineer, which you can read for yourselves, but which generally comes to this—that he has had occasion in several ways to modify various parts of the machines, and that he has got them into that position that they will do two things which it is greatly to our interest should be done. They can work with regularity and without continual breakdowns, and with much greater economy. We are suffering, no doubt, at present, and we shall suffer. It seems to be the penalty of shortcomings—I was going to say the penalty of misconduct, but I do not know whether that term could be applied to the errors of judgment in which this thing was started; though, at all events, we have lost our character with the public. Unfortunately, we also lost our turn. Everyone knows that when you want to get a particular seat in the pit at the theatre you get to the door first, and you then get in; but if you have half-a-dozen people before you, you will find the place occupied. That is what we did. We were not only late, but defective as regards our position; but the question is, do these figures that we have before us now form any encouragement to hang on on the idea that we shall retrieve our position? I think the whole thing is in the lamp; so many lamps so much money, receipts, and expenses. The greater the number of lamps the greater the receipts; the greater the number of lamps the less relative cost per lamp; and it all comes to that. When you have got 56,000, or twice 56,000, lamps going, what is the possible average you will get out per lamp? That is knowledge that we are getting. We started with contracts—so much per lamp per annum, for want of any other means. When we began this thing, and until almost recently, it was impossible to resort to any known method of measuring what we produced or sold. Happily for us, in the interim we have an effective meter, as far as a mechanical device of this delicate kind can be effective, and the character of our income has entirely changed in the last few years. A very slight portion of our income is derived from contracts now, and it all practically comes from meters, and we go by what is called the Board of Trade unit. I will not trouble you with a scientific description of the Board of Trade unit. That is a formula which has puzzled me and which must puzzle you. We were authorised to charge for that unit 7½d., and the success of this and of all similar undertakings turns upon how much you can produce it at. Hitherto we have been producing it at something more than the saleable price, which is very bad business; but it is material to bear in mind that the saleable price does depend on the multiplication of the lamps, and you will see at once what a different position we shall be in if, during the next two years, we double our number of lamps, because that will not be attended with anything like double the cost of production. In fact, it will be attended with a very small proportion of cost, and the great crucial test of this thing, as in many other great things, turns on very minute calculations of very minute quantities. If we can sell at 6d. a unit and produce at 4d., anyone can calculate how much so many hundreds or thousands of lamps in a year will give you, and it does not want such a very large number for us to get out of the slough of despond into comparative prosperity. I think I had better repeat myself, for one is obliged to get a sort of formula into the mind. We believe that the machinery we have now got at Deptford (barring the enormous dynamos, which it would be madness to go on with at present—and they must remain dead capital—but the three classes of dynamos I have described) will enable us to light certainly 90,000 lamps. For the sake of argument suppose the 90,000 should average the very modest sum of 10s. each, there is an income at once of £45,000. Our income this year was only £24,000, and the difference between £24,000 and £45,000 is pretty considerable. Our expenditure has been £28,000. That expenditure would not wholly cover the production of the additional number of lamps, but it would go a very long way towards it. There would be a perceptible addition to the £28,000, but it would be in coal largely. All the other charges would remain the same in amount but less per lamp, and what we have got to strive at is to get that down. Of course, all these things rest on very small calculations. I will give you an idea of what these quantities are—an analysis of what it costs to produce a unit of electricity, 7½d. being the estimated Board of Trade value of a unit. The number of items required to ascertain how much it costs to produce what you can sell for 7½d., or some lesser sum, is 18. As I tried to explain, a portion of that is actually dependent on the quantity you produce, but the bulk is dependent upon a number of fixed charges. In the year 1891 every unit we produced cost us 10·14d., of which 4·61d. was in the first category—generating costs—that is, coal, sundry stores, salaries, wages, repairs and maintenance, and the only thing, therefore, of a fluctuating character which would entail cost for additional quantity is the item of coal, which was 2·36d. per unit. I suppose it is possible that coal may be a little more or a little less per unit. When, however, you come to all the other charges, you have got to divide them by the number

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of units irrespective of any fact. such as that every unit means so much coal. Every unit does not mean additions to wages, rent, repairs, and maintenance of machinery ; they go revolving and wearing themselves out up to their maximum amount per revolution, and the hope of this thing turns upon what can be done by the multiplication of quantity, and, I admit, trimming down from time to time, as opportunity affords, the charges embraced in those innumerable items which come out in hundredths, and sometimes thousandths, of a decimal of a penny. Just to show how important that is, we have got the three months ending last March, when things had improved from the fact of there being more lights and the machinery having been got into better order, and we have, at some moderate expense, improved the machinery. By means of the condensing process we have diminished the evaporation, and reduced the consumption of coal. In the March quarter of this year, which included only one month of the condensing, we have reduced the cost of the unit from 8·06d. to 5·71d. Of that 5·71d.—the cost of every unit we sold in the March quarter this year—coal stands for 1·31d., and therefore, the enormous proportion of 4·40d. will be stationary, and will be diminished exactly in the proportion as the units sold increase. The only item which will progress will be the 1·31d., or some even smaller quantity per unit, for coal, and the other items embraced in the 4·40d. will diminish and diminish until the amount gets down to probably 3d. or 3½d. per unit. Then you will be able to make your calculation as to the difference between producing a unit at 8d., because you sell a limited quantity, and producing a unit at 3½d. or 4d., where you sell a considerable quantity. I hope I have made this point, which is very technical, clear, but it is very important to those whose pockets have been emptied by experiments in this business. Another important element is the price of selling. All these companies, I believe, are in a very bad position. One naturally looks into their accounts and analyses their figures, and we know as much of the details of these items of all the companies in London as we do of our own. That is our business—by comparison to see where we are. I believe they are all between wind and water ("No, no.") Never mind about "No, no."

A SHAREHOLDER : The St. James's and Pall Mall Company,

A SHAREHOLDER : And the Westminster Company.

The CHAIRMAN : Well, we will not criticise the Westminster Company ; we shall see what they do a year hence. They have all, however, been guilty of an act of folly. I will assume, if you like, that they are as innocent as angels of any want of prudence, but they have been guilty of folly in competition—unduly rushing down the rates. There was no reason why the standard adopted, after enormous inquiry and contention, by the Board of Trade as a legitimate charge, should not have been maintained until, at least, we were out of the wood. When people are prosperous and their position is such that they can pay expenses and make proper reserves, and have large reserve funds, they can begin to give the public the benefit of their excessive profits, but that is not the case with any one of these concerns. Notwithstanding that, we have all got into competition, and the rate has been reduced to 6d. Now, I suppose, human folly can hardly proceed to go further than a standard of something like 6d., under existing conditions, of course. I am not aware that the price of coal is likely to be very materially reduced ; certainly, wages are not, I think, likely to go down. What with Eight Hours' Bills, dockers' unions, and other things directly affecting coal, among others, I should think that the tendency was rather in favour of costs rising instead of falling. In face of that, to knock down a legitimate charge seems open to question ; but there it is. What we have to bear in mind is the standard—what can you sell your article at ? During this year we must take it at 6d., and that makes it very material whether we get down the rate by increase of lights, from 5·71d. to 3½d. or 4d., or some other figure within the bound of 6d. In short, it all comes to this—that the greater the quantity within a reasonable measure the less it will cost, but it is very easy, under the stress of competition, to sell a thing at a price which no cost will justify. That is, so to speak, the philosophy of it. I do not know what anyone is going to say, or what the result of this meeting may be upon the accounts, but what I want the shareholders to carry away in their minds is the only thing which is comforting us and guiding us as to the conditions affecting the sales, and to be accurately informed as to the probability of sales. We think that the probabilities are greatly in favour of our sales increasing, and increasing with reasonable rapidity. When we get double as many lights as we have got now, it will not be so very great a number, and if we get double the number it will make such a marked difference in the cost of production that there will be a considerable profit shown instead of a loss. Now, coming to the report of the Directors, it really only repeats—the bulk of it—the matter which is put there for your edification relating to the views of the engineer. Mr. D'Alton, who was second in command under Mr. Ferranti, we have felt sufficient confidence in to constitute our chief engineer, and he has fully justified that confidence in coping with the enormous difficulties which he has had to incur or to encounter in improving this machine into something like a going concern. Of course, Mr. D'Alton is a mechanic more than a scientist, a pure scientist, and I do not know what the pure scientists would do if it was not for the mechanical brake upon their fancies. But it is necessary in this unknown business to have the assistance of eminent scientists, because there are tests of the utmost delicacy which can only be carried on in a laboratory, and for that purpose we have had the great assistance and advice of Dr. Fleming, who has added to the report his approval and concurrence in what has been said by Mr. D'Alton, while he has given you some crumbs of comfort as to the result of experiments which have shown where in this concern there has been great loss, arising from faults in generating electricity and loss in transmission which have affected the Company very seriously, as you may measure by this fact: that of all the current generated and got into the mains for transmission, only about 42 per cent. is sold in the shape of units, the rest disappearing—fortunately we know now where, and although the knowledge involves the spending of more money, of a moderate amount, it is chiefly in transformers. The new transformers now in course of construction will have this marvellous effect : to reduce the waste. so that we anticipate—or these scientific gentlemen do—that instead of selling 42 per cent. to 45 per cent. of the current, we shall sell 70 per cent. certainly of the quantity produced, or more. That itself will make a vast difference. We tell you in the report about the competition, which has this possible result—that the lower the cost of electric lighting the greater the probability of people resorting to it. I know many people and some companies who have clung to gas because they compare the gas bill with the electric current bill. They think that that is the standard by which they should judge. They say, "Dear me, the electric light costs 20 per cent. or 30 per cent. more than gas, and, therefore, why should I burn the electric light ?" The cost of the electric light, however, does not mean all the benefits of it. One knows what they are. Some of them are sanitary, some æsthetic, some connected with the wall decorations, and so on, in people's houses, but these considerations are very lightly appreciated. People only look at the amount of the bill, and do not take into consideration other advantages. That is knowledge, however, which is spreading, and we believe that it will continue to do so, and it means the development of our business. Of course, the Board regret that the year's working has resulted in a deficit of £3,914. 9s. 7d., but there is some crumb of comfort in this direction, because we have narrowly watched the progress of the thing from month to month and quarter to quarter, and the last quarter of the old year—the year we are dealing with, which ended with December, 1892—and the first quarter of March, 1893, have reversed the position, which is intelligible and satisfactory. In the December quarter of 1891 there was a loss of £821, while in the December quarter in these accounts there was a profit of £1,486. That cuts double. Instead of being a loss of £821 it is a profit of £1,486, so that it is really £2,300 to the good. So, in the March quarter of 1892, there was a loss of £893, while in the first quarter of this year there is a profit of £1,113, representing something like £2,000 to the good. If that goes on, as I trust, we shall only have to wait for a year or two to emerge from a bad state of things into a comparatively satisfactory result. I now move the resolution—

"That the report and accounts now submitted be adopted."

The Right. Hon. the EARL OF CRAWFORD, K.T., seconded the motion.

Mr. BIRKIN asked whether the enormous sum of money—£248,000—paid for the purchase of the business of Sir Coutts Lindsay and Co. had proved a satisfactory purchase, which, he presumed, was recommended by the Directors. He also wished to know whether the present engineer was the gentleman who recommended the adoption of the enormous engines which the Chairman had now said were of no use. It seemed to him (the speaker) that they had to reconstruct and begin *de novo*, and he thought that that was very unsatisfactory. He could not understand why £30,000 had been paid for the cost of redeeming debentures when they had afterwards to get more money. He thought the general expenses were much in excess of what they ought to be, and he considered the Directors ought to meet the existing condition of things by suspending their fees until the shareholders received a dividend.

Other Shareholders having spoken,

The CHAIRMAN, in reply, said it seemed to him to be a choice of alternatives—whether they should take the desponding view of Mr. Barham and and make the worst of it, or accept the extremely common-sense summing up of another shareholder, and the Board preferred the latter course should be adopted. He could not imagine anyone could have a greater interest than the Directors in the undertaking being carried on, and as far as possible successfully, because they held an enormous stake in the Company. Out of the total paid-up ordinary share capital of £555,000 the Directors held £336,000, and, beyond this, they held a very fair share of the preference capital. As he had said, the undertaking was started too magnificently, and the science itself was not sufficiently developed to justify, as it turned out, views which were pleaded with eminent skill and adopted by the Board. That, however, was not a very uncommon state of things in other undertakings. No doubt, the result was unfortunate, but he had endeavoured to make out at the start where they had got to—that they had come through many difficulties, and that the position of disaster had now been sufficiently retrieved to make the future hopeful if they persevered in the course they had undertaken. As to the purchase of the business of Sir Coutts Lindsay, the company was founded upon an existing business, the purchase of which was paid, as he understood, in shares which, with a great many other shares in the Company, belonged to the Directors and their friends who went into the concern with perfect *bona fides*, and who were just as disappointed as their co-shareholders. He had said, elsewhere, and he repeated it, that he never knew any man so like the late Mr. Brunel as Mr. Ferranti, and he remembered that Mr. Brunel broke his heart and diminished his fortune by his gigantic steamship enterprise. The march of ingenuity and the wants of commerce had, however, rendered the adoption of great steamships necessary, and they had come back again. Whether Mr. Ferranti's scheme would be successful in the future or not he (the speaker) could not say, but they could not wait, and therefore must use machines which would accomodate the consumption they had now to deal with. Meantime there was no doubt that Mr. Ferranti's machines did represent a large lock-up of money. The Directors had decided in the future to suspend their fees until the Company was in a position to pay them. He would not allow for a moment that the management had been defective They sometimes had complaints from their customers, and sometimes their lights went out, but that was the case with some other companies too, and theirs was not the only company that was blamed. They endeavoured by canvassers and other means to increase their number of lights, and they could now supply 90,000.

The resolution was carried.

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The Earl of Crawford was then re-elected a Director as were Sir Coutts Lindsay and Lord Wantage, and the auditors Messrs. Kemp, Ford and Co.

A vote of thanks to the Chairman and Directors was afterwards passed, and the proceedings terminated.

The following is an abstract of the Directors' annual report for 1892 :—

The measures taken to reduce the cost of producing the current and increase the efficiency of the generating plant have proved satisfactory. Owing to the autumn being the only period of the year when extensive alterations or additions to the generating machinery can be prudently carried out, the advantages gained were but slightly felt during the past year, but, as stated in the engineer's report, the current year will realise the full benefit of the work done. As a consequence of the competition which has arisen among the several companies, the standard charge per unit has been reduced from 7½d. to 6d. The electric current at its present cost being now about equal to that of gas, the Board feel justified in anticipating a rapid extension of electric lighting.

The increase in the number of lights supplied during the past year amounted to about 40 per cent. This rate of increase has been more than maintained during the first four months of the current year, and in face of severe competition. The Board regret that the year's working has resulted in a deficit of £3,914. 9s. 7d., which is partly due to the slow rate of increase of the business in the early part of the year, and partly to the diminution in the number of units sold per lamp installed. It may, however, be observed that a comparison of the accounts shows that, whereas in the December quarter of 1891 there was a loss of £821. 5s., there has been a profit of £1,486. 15s. 10d. in the corresponding quarter of 1892, and that in the quarter ended March, 1892, there was a loss of £833. 13s. 1d., there has been a gain of £1,113. 8s. 8d. in the corresponding quarter of the current year. Major C. B. Waller, formerly manager and secretary, has been elected a Director in the place of Mr. Arthur F. Wade, resigned. Mr. Henry F. Lewis, for many years general manager of the Western Counties and South Wales Telephone Company, has been appointed general manager ; and Mr. R. Stewart Bain, the accountant, has—while retaining that post—been appointed secretary.

Particulars of the working of the Company's system will be found in the reports below.

Report by Mr. P. W. D'Alton, engineer-in-chief, dated May 4, 1893 :—

"During the past year the working has been satisfactory, and many improvements in mechanical and electrical details have been made with the best result ; so that, of late, the interruptions in the supply of current have been few and unimportant. At the commencement of the year we had 35,100 lights connected. At the end of the year the number had increased to 46,197. Up to the present date the number amounts to 56,200 lights, and we have orders for a considerable number of lamps in course of execution.

Important additions have been made to the generating and other plant. A new dynamo of 300 H.P., driven by a set of triple-expansion condensing engines, has been erected, from which we have obtained excellent economical results. This machine is able to deal with the early-morning load during a considerable part of the year. A machine of similar size is now being built for us, which, when brought into use, will enable us to work our daylight load with greater economy than has hitherto been possible. These machines will constitute a useful auxiliary power, as they can be worked in parallel with the larger machines with considerable economy. The remodelling of the two 625 H.P. dynamos has been effected, and the output of the machines increased from 8,500 lights to 12,500 lights each, an advantage which has been secured by a relatively small outlay. The high-tension transformers, which gave us so much trouble in previous years, have done their work well. This I attribute to the careful and intelligent manner in which these instruments have been overhauled in our repairing departments at Deptford.

The trunk mains have worked satisfactorily during the year. They were very seriously threatened, and suffered considerable damage, by two fires which occurred on premises contiguous to the mains. To safeguard us in future from such consequences, I am now laying underground mains in substitution for those affixed to the S.-E. Railway parapet. When this work is completed the whole of our trunk mains will be underground, with the exception of the short section which crosses the river by Charing Cross Railway Bridge.

During the year we have laid down eight miles of distributing mains, making a total of about 35 miles of this description of main, all of which are in a satisfactory condition. The whole of the distributing stations now in use are fully equipped with the permanent switching gear, and these stations are working well. The system for condensing the exhaust steam has been completed during the year, and has been in work for some months past with the economical and mechanical advantages which I anticipated. The generating and distributing plant has been kept during the year in good order, and is working to my entire satisfaction.

Dr. J. A. Fleming, consulting engineer to the Company, reports under same date :—

I have read the report of your engineer, and substantially agree with the same. In addition to the remarks made by him, I may add that at the beginning of the year 1892 I began to carry out a careful series of experiments on the energy losses in the house-transformers. The result of this investigation was to show that an immense improvement could be effected in the Corporation's system by replacing the existing house-transformers by others of a more modern type. This work you have now sanctioned, and it is being carried out, and the result will be to effect a great economy in fuel. In the course of these experiments we discovered a very simple method of regulating electric pressure, which we have applied to the trunk mains with satisfactory results, in that we are now able to connect and disconnect mains without producing changes of electric pressure injurious to them.

The high-tension transformers have, during the last year, given very little trouble. The methods of connecting and disconnecting them to the circuits have been so far perfected that failures of these transformers are now very rare. When the replacement of the whole of the house-transformers is effected, and when the other improvements described by your engineer are all fully at work, I think there is every reason to believe that the system of supply will, so far as economy and efficiency of working is concerned, compare very favourably with other systems.

Yorkshire House-to-House Electricity Company (Limited).

The annual meeting of the shareholders of this Company took place at the offices, Whitehall-road, Leeds, on Friday, Mr. Grosvenor Talbot in the chair.

In moving the adoption of the report, which was published in *The Electrician* of May 5th, the CHAIRMAN said it only showed a very small part of the work that had been done. Since December 31st they had considerably advanced ; they had opened their works, and they should have very much more to tell the shareholders a year hence. The Directors considered that they had done well, and the presence of so many people from various parts of the country at the opening of their works on Wednesday showed that there was evidently great anxiety on the part of large towns throughout the United Kingdom as to obtaining the best system of electric lighting. They trusted that their works were on the best existing plan, and there was every reason to believe that they would be efficiently conducted by the Directors, for their coal and water were cheap and their situation good. They felt sure that the works would be keenly criticised, but he hoped they should do everything in their power to make them a success. He thought the shareholders would join in the opinion of the Directors that so far they had proceeded in the right direction, and it now remained for them to go further and make the works which they had commenced a successful paying concern. They could with their plant provide current for 5,000 or 6,000 lamps more than they were now supplying, and when these were taken up they trusted they should be able to get additional capital for the extension of their plants. In conclusion, the Chairman explained that the expenses in connection with the opening of the works did not fall upon the shareholders in the slightest degree.

Mr. ROBERT HUDSON seconded the motion, and the report was unanimously adopted.

Messrs. Robert Hudson and Samuel Ingham were afterwards re-appointed on the Directorate, and Mr. John Gordon, jun., was re-elected auditor.

In reply to an inquiry from a shareholder, the CHAIRMAN stated that with their present plant they could supply 16,000 8-candle lamps, and that between 10,000 and 11,000 lights had been applied for up to the present.

The meeting then concluded with a vote of thanks to the Chairman.

China and Japan Telephone Company (Limited).

The tenth ordinary general meeting of this Company was held at the offices, 14, Austin Friars, E.C., on Tuesday, Mr. Thomas Lloyd presiding. We have been supplied with the following report of the proceedings :—

The SECRETARY (Mr. Alex. B. Chalmers) read the notice convening the meeting.

The CHAIRMAN : Gentlemen, the report and accounts have been in your hands for some days, so I presume you will take them as read. I do not know that I need detain you with very many remarks. The Company is doing satisfactorily, and we carry forward a favourable balance. The business looks improving in spite of difficulties in regard to the depreciation of silver. Mr. Porter, our manager in Shanghai, has been, as some of you know, at home for a year, and has reported very favourably as to the future. Mr. Harrison, the Company's representative at Hong Kong, has put that agency on a better footing, and the latest accounts from him are decidedly encouraging. I now beg to move—"That the Directors' report and the audited accounts for the period ending 31st December, 1892, be, and they are hereby approved and adopted."

Mr. GREWING seconded the resolution, which was carried.

Mr. GREWING then proposed—"That Mr. Thomas Lloyd be re-elected a Director of the Company," which was seconded by Mr. W. ADDISON, and carried.

The retiring auditors having been re-elected, it was proposed by Mr. W. ADDISON that a sum of two hundred guineas be voted to the Directors for their services during the past year. The motion having been seconded and carried, the proceedings terminated.

The following is the Directors' report :—

The revenue account for the year ending December 31, 1892, after charging interest on debentures, shows a balance to credit of £549. 15s. 7d., which has been transferred to profit and loss account. Including £627. 9s. 11d. brought forward from 1891, the amount to credit of this account is £1,177. 5s. 6d. The expenditure on capital account being £482. 2s. 2d. in excess of the share capital and debentures issued, it is proposed to charge profit and loss with that sum by writing off the amount to credit of capital account, and to carry forward the balance, viz., £695. 3s. 4d. There has been an increased business during the year at both Shanghai and Hong Kong, but the fall in exchange consequent on the depreciation of silver has affected the final result of the year's accounts, the amount charged in the accounts in respect of this item being £243. 19s. 4d.

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Elmore's Patent Copper Depositing Company (Limited).

The adjourned extraordinary general meeting of this Company was held on Friday last, at the Cannon-street Hotel, E.C., Mr. J. Todhunter, J.P. (one of the provisional Directors), in the chair.

The CHAIRMAN said that the subscriptions to the required sum of £17,600 amounted to only about £12,000, and the Committee had pledged themselves that, if the whole amount were not forthcoming by Tuesday last, the cheques received should be returned. On his own responsibility he had approached some financiers with a view to obtaining funds, and two days ago he had an absolute promise of a guarantee of the whole capital that would be required for the reconstruction of the Company; since then there had been a panic in financial circles, and the offer was withdrawn. He proposed that the Company should go into voluntary liquidation, and sell the assets to a new company, with a nominal capital of £200,000, with 182,390 shares of £1 each, carrying a liability of 3s. on each share, each shareholder in the existing Company to receive two shares of £1 each for every £2 share now held by him. That would provide a working capital of about £10,000, which was absolutely necessary to complete the machinery and put the works on a proper basis. From personal knowledge and inspection he was confirmed in the opinion that the process was a success. He therefore proposed the adoption of the scheme.

Mr. INVERARITY suggested the issue of a circular, inviting the shareholders to subscribe *pro rata* towards the £5,000 now required.

Mr. F. L. RAWSON proposed as an alternative scheme the creation of second mortgage debentures, with the option of holders exchanging at any time into ordinary shares.

Ultimately, a canvass of the shareholders in the room was taken, when subscriptions for preference shares were announced to the extent of £2,730, in addition to the £12,000 promised. It was also decided that the secretary should issue a circular appealing for funds.

A resolution was then moved and adopted:—"That, in the event of the money not being forthcoming by Tuesday, the Directors be requested to convene a special meeting to wind up the Company with a view to reconstruction."

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1893, pages 320-348, *&c., &c.*]

BOURNE AND GRANT ELECTRICITY SUPPLY COMPANY (LIMITED).—This Company was registered on the 13th inst. with a capital of £25,000, divided into 24,900 ordinary shares and 100 founders' shares of £1 each, to carry on the business of an electric light, heat, and power supply company in all or any of its branches, and to carry on the business of electricians, electric light contractors, electrical and mechanical engineers, suppliers of electricity for the purpose of light, heat, motive power, or otherwise, and manufacturers of and dealers in electrical apparatus of every description.

COVENTRY ELECTRIC TRAMWAYS (LIMITED).—This Company was registered on the 10th inst., with a capital of £25,000 in £5 shares, to acquire railways, tramways, &c., in the United Kingdom; to construct, maintain, work, equip, lease, or obtain running powers over, or to dispose of, such railways or tramways; to adopt and carry into effect an agreement dated May 5, 1893, and made between the Electric and General Contract Corporation (Limited) and Alfred G. Jones (as trustee for the present Company); and to carry on the business of contractors for electric traction, carriers, electrical and general engineers, electricians, suppliers of electricity, and manufacturers of and dealers in electrical and scientific apparatus.

MISCELLANEOUS.—THOMPSON BROTHERS (LIMITED), mechanical and electrical engineers, gas-oven makers, and iron and brass founders; capital, £7,000 in £1 shares.——WEST HAMPSTEAD FOUNDRY AND ENGINEERING COMPANY (LIMITED), mechanical and electrical engineers, iron and brass founders, machinists, &c.; capital, £15,000 in £1 shares.

J. E. H. ANDREW AND CO. (LIMITED).—The annual return of this Company made up to April 13th has been filed. The nominal capital is now £40,000 in £20 shares, 1,465 shares have been taken up, of which 300 have been issued as fully paid. Upon the remaining shares a call of £20 per share has been made, resulting in the payment of £24,000, which includes a sum of £700 paid on 35 forfeited shares.

ANGLO-PORTUGUESE TELEPHONE COMPANY (LIMITED).—The annual return of this Company, made up to April 11th, has been filed, and shows that out of a nominal capital of £75,000, in £1 shares, 50,000 shares have been taken up, all of which have been issued as fully paid. Of these share warrants comprising ten shares each are outstanding to the total amount of £4,020.

BERNSTEIN ELECTRIC LAMP COMPANY (LIMITED).—The Registrar of Joint-Stock Companies has been informed by Mr. D. Havelock Fisher, the secretary, that although no business has been done by the Company during 1892, the patents are being kept valid, and the Company will be kept on in the hope of business being renewed.

BIRMINGHAM ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of this Company, made up to March 20th, has been filed. The nominal capital is £100,000, in £5 shares, all of which have been taken up. The full amount has been called on 10,000 shares, and £2 per share on the remainder, resulting in a total payment of £70,000.

CHAMBERLAIN AND HOOKHAM (LIMITED).—The annual return of this Company made up to April 26th has been filed. The nominal capital is £100,000, divided into 5,000 "A" and 5,000 "B" shares of £10 each; 1,000 "A" and all the "B" shares have been taken up, the latter having been issued as fully paid to the vendors. Upon the "A" shares a call of £3. 10s. per share has been made, and all calls have been paid.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The second annual return of the above-named Company, made up to April 27th, has been filed; 20,000 preference and 40,000 ordinary shares have been taken up, out of a nominal capital of £800,000, divided into 40,000 preference shares of £10 each, and a like number of ordinary shares of £10 each. The full amount has been called on the ordinary shares, while a call of £8 per share has been made on the preference shares. The calls paid amount to £560,000.

DOMINION ELECTRICAL COMPANY (LIMITED).—The statutory return of this Company, made up to March 10th, has been filed, and shows that out of a nominal capital of £25,125, divided into 5,000 ordinary shares of £5 each and 500 founders' shares of 5s. each, 1,000 ordinary and all the founders' shares have been taken up. Upon the founders' shares the full amount has been called, while each of the ordinary shares has had £1. 5s. called upon it. The calls paid amount to £1,750.

NOTTINGHAM ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—A meeting of this Company (in voluntary liquidation) is to be held at 29, Low-pavement, Nottingham, on June 12th, at 4 p.m., to receive the liquidator's report of the winding-up.

WILLIAMSON ELECTRICAL ENGINEERING COMPANY (LIMITED).—At a meeting of the Company, held on the 2nd inst., at 14, St. Ann's-square, Manchester, it was resolved to wind up the Company voluntarily. Mr. J. E. Sharples, of the above address, was appointed liquidator, and claims must reach him by October 2nd.

WOODHOUSE AND RAWSON ELECTRIC MANUFACTURING COMPANY (LIMITED).—A meeting of this Company is to be held at Room 433, 11, Queen Victoria street, E.C., on June 16th, at 3 p.m., to receive the liquidator's account of the winding up.

WOODHOUSE AND RAWSON UNITED (LIMITED).—A petition for the winding up of this Company has been presented by W. T. Henley's Telegraph Works Company (Limited), and is directed to be heard at the Royal Courts of Justice, on the 7th prox.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended May 14th were £787, as against £769 for the corresponding period of last year, being an increase of £78. The total receipts for the half-year amount to £16,940, against £15,607 in the corresponding period of 1892, being an increase of £1,333.

GENERAL ELECTRIC COMPANY (U.S.A.).—The first annual report of this Company, which was incorporated in April, 1892, has just been issued. It will be remembered that the Company acquired the capital stock of the Edison General Electric Company, the Thomson-Houston Electric Company, and the Thomson-Houston International Electric Company. The report shows that the Company has about 6,000 customers, and that the chief increase in the business since the incorporation has been in the lighting and railway departments 1,277 local lighting companies, who are customers of the General Electric Company, are stated to be supplying about two and a-half million incandescence and about 110,000 arc lights, and the increase in mileage of the railway companies using the Edison and Thomson-Houston systems has increased from 2,315 miles in 1892 to 4,927 miles in 1893: whereas in 1892 the largest power generators manufactured was of 275-H.P. machines of 2,000-H.P. are now being manufactured. The largest lighting generators at the same date were for 2,000 incandescence, and are now being constructed for 12,000 lights. Considerable progress has been made in the development of electrical apparatus for mining purposes and in particular of locomotives for haulage work, for which the Company have a large number of orders for early delivery. The report states that in addition to the actions which it has been found necessary for the Company to take during the past year to protect these patent rights, other actions are in progress, and are to be pushed on as vigorously as possible. The Company are represented to be supplying plant and apparatus to about 1,300 local companies who are paying royalties from 1,500,000 dollars to 2 millions dollars per annum. The Company is making much progress and is paying regular quarterly dividends.

REUTER'S TELEGRAM COMPANY (LIMITED).—Notice is given that the twenty-ninth ordinary general meeting of the shareholders of this Company will be held on Wednesday, the 31st inst., at 12 o'clock at the offices, 24, Old Jewry, E.C., for the reception of a report and balance-sheet from the Directors, the declaration of a dividend, and the election of a Director and auditors; and to pass a resolution with reference to the Superannuation Fund.

THE LATE SIR JAMES ANDERSON.—At the Board meetings of the telegraph and other companies with which the late Sir James Anderson was associated, feeling references have been made during the past week, and votes of condolence with his family, expressing a high sense of the eminent services rendered by him to submarine telegraphy, have been unanimously passed.

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STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to appoint a special settling day in and to grant a quotation to 20,510 shares (Nos. 1 to 6, 215 to 718, and 10,001 to 30,050) in the Charing Cross and Strand Electricity Supply Corporation (Limited).

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended May 12, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,741.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 10.		Price Wednesday, May 17.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May 17.	
								£ s. d.		Highest	Lowest.
			TELEGRAPHS								
£1,247,720	Stock	12/6	Anglo-American	51½	52½	50½	51½	5 6 10	Jan., Apr., July, Oct	51⅞	51¼
£2,876,140	Stock	25/0	Do. Preferred	93	94	91½	92½	5 18 11	" "	93⅝	92
£2,876,140	Stock	5/0	Do. Deferred	12½	13	11½	11⅝	..	" "	12⅜	11⅜
£250,000	100	4%	African Direct, Telegraph 4% Debentures	101	104	101	104	3 16 11	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11¾	12¼	11¾	12¼	5 6 1	Mar., June, Oct., Dec.	12	11¾
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107	111	107	111	4 10 1	June and December	..	..
$7,716,000	$100	$1½	Commercial Cable Capital Stock	140	150	140	150	4 13 4	April and October	..	..
16,000	10	8/0	Cuba Submarine	11½	12½	11½	12½	6 8 0	February and August	..	..
6,000	10	10%	Do. Preference 10%	18½	19½	18½	19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½	3½	2½	3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11¾	12	11¾	12	5 13 8	Jan., Apr., July, Oct	12	11¾
400,000	10	2/6	Eastern	15⅛	15⅜	15⅝	15⅝	4 3 2	" "	15 1/16	15⅛
70,000	10	6%	Do. 6 per Cent. Preference	16½	17	16½	17	3 10 7	" "	..	..
£1,294,030	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	113	116	113	116	3 9 0	May and November	114	113
£105,990	100	5%	Do. 5 per Cent. Debentures 1899	108	111	108	111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	15¾	16	15¾	16	4 7 6	Jan., Apr., July, Oct.	16⅛	15¾
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114	117	114	117	3 8 5	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	104	107	104	107	4 13 6	January and July	..	
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103	106	103	106	4 14 4	" "	..	..
£100 000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101	104	101	104	3 16 11	February & August	..	..
1:0,2 7	10	2/3	Globe Telegraph and Trust	9⅞	10⅛	9⅝	9⅞	4 11 2	Jan., Apr., July, Oct.	10	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	15⅝	16	15⅝	15⅞	3 15 7	" "	16⅛	15⅞
150,000	10	7/2	Great Northern	19	19½	19	19½	4 7 2	Jan., April, and July	19½	..
£220,000	100	6%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	107	..
17,000	25	37/6	Indo-European xd and Bonus	43	46	41	43	5 16 3	May and November	..	..
38,348	10	4/0	London Platino-Brazilian xd	4	6	4	6	6 13 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
10,802	8	4/0	Reuter's	7	8	7	8	..	April and October	..	..
3,381	£100 Cert.	30 0	Submarine Cables Trust 6%	121	126	120	125	4 16 0	" "	..	..
15,609	10	5/0	West African Telegraph	5½	6½	5½	6½	7 13 10	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100	103	100	103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	2	3	2	3	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	June and December	101¾	..
88,321	10	6d.	West India and Panama	1⅛	1⅜	1¼	1⅜	..	" "	1⅜	1¼
34,563	10	6%	Do. 6 per Cent. 1st Preference	11½	12	11½	12	5 0 0	May and November	11⅞	11½
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9½	10½	9½	10¼	5 14 3	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	108	111	108	111	4 10 1	June and December	..	..
64,242	15	4/6	Western and Brazilian xd	7½	8½	7⅝	8	4 13 11	May and November	8	..
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred xd	6	6½	5⅞	6⅛	6 0 1	" "	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1⅜	2¼	1⅜	2¼	..	" "	2	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	107	110	107	110	5 9 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106	109	106	109	5 10 1	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	101	104	101	104	5 15 5	March & September	101¼	..
			TELEPHONES.								
40,000	£5	10/0	Chili Telephone (fully paid)	3	4	3	4	..	..	—	—
224,850	14/0	1½d.	Consolidated Telephone Const. & Maintenance	1/16	1/8	1/16	1/8	..	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	¼	½	¼	½	7 18 2	Yearly	..	..
454,747	5	2/6	National	5⅛	5⅜	4⅞	5⅛	5 17 1	June and December	5⅛	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15	15½	15	15½	4 17 6	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14½	15	14½	14⅞	4 1 4	" "	..	..
90,950	5	6⅜d.	Do. 5% Non-Cumulative 3rd Pref. (£3 paid)	5⅛	5⅜	5⅛	5⅛	..	..	5 7/16	5⅛
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	113	116	113	116	3 17 7	January and July	114½	113¼
48,000	£10	..	New Telephone, Limited (£4 paid)	..	..	..	..	..	..	..	..
58,000	5	1/0	United River Plate	2	3	2	3	..	January and July	..	..
	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (fully paid)	12½	12⅝	12	12½	—	—	12⅝	12¼
20,000	£10	..	Do. 6 per Cent. Preference (£4 paid)	10½	11	12½	13	..	..	10¼	10⅛
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	—	—	—
£150,000	£5	..	Electricity Supply Company Ordinary	5	5¼	..	..	..	—	..	..
£47,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	—	..	—
8,332	£5	..	House to House Electric	1½	2½	1½	2½	..	—	—	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully pd.)	5⅜	5⅝	5⅜	5⅝	..	..	..	—
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	6	6½	6	6½	..	January and July	..	..
20,000	£5	..	Liverpool Electric Supply (£3 10s. paid)	4¼	4½	4¼	4½	..	..	..	—
10,000	£5	..	Do. (fully paid)	6	6½	6½	6⅝	..	..	..	..
111,000	5	..	London Electric Supply	..	..	⅞	1⅛	..	—	..	..
43,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6½	6⅞	6	6⅛	3 1 6	—	..	..
£50,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, & £40)	101	104	102	105	4 15 3	June and December	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	5	6	5	6	—	—	..	..
18,680	£5	9½%	St. James' and Pall Mall	7⅞	8⅛	7⅞	8	..	—	7⅞	..
7,900	£5	7%	Do. 7% Preference	8	8½	8	8½	4 2 4	—	8⅜	8⅛
42,853	5	2/0	Westminster Electric Supply (fully paid)	5½	6	5½	6	2 18 4	—	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/6	Brush Electrical Engineering	3½	3¾	3	3¼	..	—	3 7/16	3⅛
69,996	2	6%	Do. 6 per Cent. Preference	2¼	2½	2⅛	2⅜	5 1 1	—	2⅜	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	109	111	108	110	4 1 0	..	109½	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref Shares	5¼	5⅜	5¼	5⅜	6 1 9	January and July	5⅜	..
12,139	5	..	Edison and Swan United	..	..	..	..	..	—	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	1¾	2⅛	1¾	2⅛	..	—	..	..
45,000	10	12/0	Electric Construction	2⅛	3	2⅛	2⅜	..	—	2⅜	2⅛
70,000	2	10/0	Elmore's Patent Copper Depositing	⅜	⅝	½	⅝	—	—	⅝	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1	2	1	2	..	—	..	..
50,000	10	15/0	India Rubber, Gutta Percha &c., Works	23	24	23	24	5 4 2	February & August	23⅜	23½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½	3½	2½	3½	..	..	..	..
11,334	£10	..	Do. Preference	..	..	..	..	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	5/0	6/0	5/0	6/0	..	..	..	..
78,949	5	4/2½	Swan United (£3. 10s. paid)	3	3½	3	3½	10 0 0	May and November	..	..
37,350	12	24/0	Telegraph Construction and Maintenance	30	32	30	32	5 12 5	March and July	32½	31
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102	105	102	105	4 15 3	January and July	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	..	..	..	..	—	—	..	..
..	£5	..	Do. Preference (fully paid)	..	..	..	..	—	—	..	..
			RAILWAYS AND TRAMWAYS.								
63,000	£10	..	City and South London Railway	..	..	..	..	—	—	..	..
500,000	Stock	2%	Do. Stock	37	39	37	39	2 17 8	May and November	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 784.—Vol. XXXI. FRIDAY, MAY 26, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

As will be seen by a Note in another column, the Municipal Corporations Association and the London County Council have been moved to take part in the Telephones *v.* Electric Traction Battle. The case for electric traction is, we have always contended, a strong one. Unfortunately, it has, until lately, lacked lucid exposition just where it was most needed, namely, at Westminster, and it has been without influential backers. With the signatories of last week's manifesto, the Municipal Corporations Association, and the London County Council all bestirring themselves, these two factors of success will no longer be absent.

The ingenious magnetic curve tracer of Prof. Ewing appeared at the conversazione of the Royal Society a fortnight ago in its final practical shape. The earlier form of this instrument, and the curves produced by it, have already been described in our columns. Engineers have been long familiar with the measurement of the area of indicator diagrams for arriving at the power developed by steam-engines, and it is safe to say that, out of every three who can thus make a satisfactory calculation of I.H.P., only one can give an intelligent account of the information about valve-setting and other details which are revealed by examination of the diagram. Similarly, we hope that this instrument may be practically used by those who do not aspire to master the intricacies of the phenomena of the magnetisation of iron. Having sample bars as a guide, manufacturers should be able to acquire valuable relative information about their iron, even if they do not trouble themselves about ergs per cubic centimetre. We should like to see this instrument in the laboratories of iron manufacturers, for it is to them that dynamo-makers may reasonably look for guarantees, or, at all events, offers of suitable material. We may observe that the curves, Figs. 5 and 6, in the article in our present issue, are one-fifth the size of the curves drawn by the apparatus itself. The dots show the actual readings, and the smoothness with which the curves run through them are a singular proof of the accuracy of the instrument.

At one time there was an idea that nothing could touch Swedish charcoal iron. Then Lowmoor iron, unrivalled for softness for certain mechanical work, was supposed to be equally unapproachable for field magnets. Then Kirkstall Forge undertook to anneal forgings for some thirty days or so for patient dynamo-builders. This groping about for good magnet iron was hard enough; but the great difficulty was to attain uniformity. A small maker might by accident turn out good material, but, not knowing why, could not reproduce it. Safety thus lay in obtaining material only from large producers. For armature cores, for which Prof. Ewing's instrument presents special advantages, the dynamo-maker has happily been assisted by the fact that iron which is magnetically bad cannot be rolled out into thin plates. But, as in the case of iron wire to which the same observation applies, repeated annealing tends to burn "the nature" out of it, to use a time-honoured ambiguity. We have more than once expressed a hope that iron manufacturers, many of whom are already equipped with excellent laboratories, might be induced to study the requirements of dynamo-makers. A knowledge of the magnetic properties of their brands would be useful, but the real question, and one which the electrician cannot be expected to attempt, is the relation between these properties and the chemical constitution of the iron.

The automatic insulation indicators used in Berlin seem to be well worth the attention of English engineers. It is strange that while such enormous sums have been spent, not only in copper, which may be expected to last for an indefinite time, but in insulating materials the life of which but little is known, and while much has been sunk in the labour of laying electric-supply mains, the safety of this valuable property is left very much to chance; and when a fault occurs, the guess of the foreman is generally taken as the best indication of the whereabouts of the accident. In America a regular staff of "trouble-men" are employed, and by long experience quickly discover the nature and exact locality of a short circuit or "ground." The Berlin system, which is described in another column, provides a continuous watching of the insulation by means of a system of pilot wires and relay indicators. Pilot wires for voltmeters are common enough in this country, but some engineers find that they have more trouble with the faults in the insulation of their pilot wires than with the whole of the rest of their lines. When once such a system as the one used at Berlin is introduced, it must be carried out thoroughly, for the earthing of the network at numerous points through pilot wires and relays would interfere with other modes of testing the insulation.

Mr. Thomas Fletcher in the opening lines of his letter, which will be found in our Correspondence columns, uses

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hard words about Mr. DOWSING's communication of last week; but whatever was lacking in that will be found in Mr. BINSWANGER's letter in our present issue. Mr. BINSWANGER's calculations agree excellently with those to which we referred last week, and are practically identical with those of our correspondent, Mr. LESLIE MILLER. Mr. BINSWANGER takes a pint of water at 15°C. and 1,000 watts, and arrives at 3·383 minutes for the theoretical time required to boil it. We took a pint at 20°C., and allowing five minutes, found that 625 watts would be required. We went on to admit that half a cubic foot of gas costing (at 3s. per 1,000) 0·0182d. would do the same, and are glad to take this opportunity of stating that, in arriving at this estimate, we consulted the figures published by Mr. FLETCHER. We attempted, at the same time, to ascertain from the same source the specific heat of a mutton chop; but could only guess that it was probably not much above 0·5. Our estimate of the gas consumption appears to be very much below the mark, if applied to the boiling of a single pint of water. The efficiency of 10 or 11 per cent., which Mr. BINSWANGER claims to have attained with a kettle, is remarkable; but it should be observed that, as we pointed out last week, the cost of warming-up is a great burden on electrical heating. In his test of an oven, it appears that, while the whole operation took two-thirds of a supply unit, the warming-up took nearly one-half of this, or one-third of a unit. The units spoken of by Mr. FLETCHER, by-the-bye, are, of course, thermal units.

In view of the recent crop of high-frequency alternators, it may be interesting to note that as long ago as 1849 PULVERMACHER invented an alternator which had a frequency of several thousand periods per second. This machine had an armature with 40 poles, so that if coupled to a Parsons steam turbine running at 8,000 revolutions per minute, it would have a frequency of 2,667 $\sim$ per second. Both field-magnets and armature were constructed of laminated iron plates, and in order to work with a microscopic air-gap, arrangements were provided for setting the armature concentrically with the magnets. To satisfy the prevailing demand for big figures, we may observe that if PULVERMACHER's alternator had been started running forty-three years ago, it would by this time have completed upwards of 7,230,000,000,000 alternations. In this calculation no account has been taken of the extra day in the leap-years.

THE Chicago Exhibition has, we must frankly confess, been somewhat of a strain upon our small stock of philosophy. A new era gets itself "inaugurated" with about ·01 per cent. of the fuss that has been made over this raree show. But now that the dollared public have been permitted to gaze upon an archipelago of packing-cases encircled by a sea of mud, the English language threatens to give way under the tremendous demands made upon it by its transatlantic users in their vain endeavours to write up to the height of the occasion. An American contemporary, devoted to tramways, remarks that as a rule the actual falls lamentably short of the ideal, but not so in the case of the Chicago Exhibition, where "no such regret will be expressed, for the simple reason that it does not lie within the power of writer and artist to convey anything like an adequate conception of the beauty, extent, and grandeur of the World's Fair. From its inception the work has been prosecuted with that tremendous energy which has built up a city of a million and a-half in half a century, and whose citizens, from the multi-millionaire down to the day labourer, have gladly contributed according to their means and expended fifteen millions of money in providing an aggregation whose equal the sun has never shone upon before. It is but truth, and in no measure exceeding the bounds of modesty, to say that what Chicago has done in this great enterprise would not, and, indeed, could not, have been accomplished by any other city on the continent, nor by any city on the globe within the same time."

THE "car fender," a transaltantic contemporary gravely informs us, "is a subject which may well enlist the consideration of the thoughtful manager." Not being acquainted with American tramway practice, we will take that statement as correct. When, however, we are asked to believe that "as a matter of economy in self-protection alone the fender would seem to admit of little argument in most cities and towns," we have no hesitation in professing our preference for the contents of a fender—which may be expressed by the well-known formula, Pkr + Tngs + Shvl—as being operators of far greater value as a means of self-protection than the fender itself.

Cardiff.—The Local Government Board has sanctioned the electric lighting loan of £32,500.

The Electric Lighting of the British Museum.—The substitution of incandescent lamps for arc lamps is in process of being carried out at the British Museum.

The American Philosophical Society.—The American Philosophical Society is celebrating its 150th anniversary at Philadelphia this week by a series of scientific and social assemblies.

The Board of Trade.—The President of the Board of Trade has appointed Mr. Francis J. S. Hopwood to be Assistant Secretary of the Railway Department, in the room of Sir Courtenay Boyle, K.C.B., promoted.

The Proposed Electric Railway in Berlin.—The proposed Berlin elevated electric railway has, says the *Engineer*, been blocked for another year, on the ground that it would interfere with services in a church.

Electric Traction at Bordeaux.—The Thomson-Houston International Electric Company has signed a contract with a Bordeaux Tramway Company to equip its system with electrical apparatus by September 30th next.

The Forthcoming International Electrical Congress at Chicago.—The five English delegates at this Congress will be Mr. W. H. Preece, Prof. W. E. Ayrton, Major Cardew, Mr. Alexander Siemens and Prof. Silvanus Thompson.

The Discussion on Mr. W. B. Sayers' Paper.—We have held over our report of the discussion on Mr. W. B. Sayers' Institution Paper, printed in our last issue, until next week, in order that our readers may have it complete and revised.

A Large Electric Traction Order.—The Westinghouse Company recently received a contract from the Philadelphia Traction Company for 600 electric railroad motors and 8,500 H.P.

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generators. It also has the contract to supply all the electrical apparatus.

The Statue of Claude-Chappe.—The Statue of Claude Chappe, the inventor of the semaphore telegraph, is to be inaugurated on July 13th next. The Paris Municipality has granted a site. The subscription started by the French Telegraph Administration reached a total of £1,400.

Cable Interruptions and Repairs:—

	Interrupted.	Repaired.
Para-Maranham	March 20th. ...	May 21st.
Assab-Massowah	March 15th. ...	May 25th.
Paramaribo-Cayenne	April 15th. ...	—
Santiago de Cuba-Mole St. Nicholas.	April 20th. ...	—

Appointments.—Sir John Pender has accepted the Chairmanship of the Brazilian Submarine and Direct Spanish Telegraph Companies. Mr. J. Denison Pender has been appointed Managing Director of the Eastern, Eastern and South African, and West African Telegraph Companies, in place of the late Sir James Anderson.

A New Wimshurst Machine.—Mr. Wimshurst has brought out a new type of influence machine. It consists of two similarly-rotated plate-glass discs placed about $\frac{3}{4}$in. apart. In the intervening space there are four vertical sheets of glass upon each of which there is a paper inductor. Brushes bear upon the inductors and upon the outer edges of the discs. There are also neutralising brushes.

The Telephones and Electric Traction.—At a meeting of the Council of the Municipal Corporations Association last week, the action of the National Telephone Company in regard to tramways worked by electricity was discussed, and a resolution proposed by the Town Clerk of Manchester, and seconded and supported by the Mayor and Town Clerk of Leeds, was passed, declaring that the matter was of such importance that it should be dealt with on Thursday, June 1st.

Electric Traction at Bangkok.—The *Indian Engineer* gives the following particulars with regard to the "Short" electric tramway at Bangkok. The plant consists of two 80-H.P. McIntosh-Seymour engines running at 284 revolutions, and two 100-ampere 500-volt generators. The overhead wire consists of No. 2 hard-drawn copper, and is suspended by steel brackets and insulated hangers from poles at the side of the road. The entire length of 17,200ft. is in three pieces only, joined by two sleeve joints. The cars are provided with 20-H.P. motors.

Munich.—The streets in the central part of Munich are to be lighted by electricity. It is proposed to utilise the water-power of two places near the town, and the whole work will be carried out before October next by Messrs. Schuckert and Co. of Nuremburg. Three hundred arc lamps are provided for, and by means of accumulators the town hall will be lighted with 1,800 incandescent lamps of 16 c.p. each. It is anticipated that before long double the original number of arc lamps will be wanted. The arc lighting is to be carried out on the three-wire system, each dynamo giving 250 volts, so that 550-volt arc lamps can be grouped in series across each branch.

Defining the Candle-power of Arc Lamps.—In a letter addressed to Prof. Elisha Gray, Chairman of the Electrical Congress Committee, the representatives of various electric-lighting interests in Chicago call attention to the confusion which is caused by designating arc lamps as of 2,000 c.p., 1,200 c.p., &c. The following is proposed for discussion and adoption by the forthcoming Congress:—"The term 2,000 c.p. is to mean an arc produced by 10 amperes and 45 volts potential-difference between the carbons, or a 450-watt arc. The candle-power of arcs produced by currents of more or less amperes, or more or fewer volts difference of potential to be rated proportionally."

The Town of Ampere.—A promising commencement of a town, with one of the fathers of electricity as its tutelary genius, has, say the *Electrical World*, been made in New Jersey, and the indications are that it will prove worthy of the great name it bears. At present the great establishment of the Crocker-Wheeler Electric Company, the electric enamelling works of George Cutter, and a pretty railway station are the only buildings. The Crocker-Wheeler Company have purchased six acres of land, and extensive buildings in which they will carry on their manufacturing are being fitted up. Shafting is entirely dispensed with, electric circuits of copper rods, tapped at intervals to supply the motors, taking their place.

The Electrical Utilisation of Water Power.—A company has been formed in Zurich with a capital of £40,000. It is proposed to establish a central station in which the water power of the Sichl, near Wedensweil, will be utilised. It is estimated that 1,300 H.P. will be available.—Plans have been prepared for the electric transmission of power from Snoqualmie Falls to the City of Seattle, Wash. The falls, it is estimated, will furnish some 32,000 H.P. at all seasons of the year; the distance to Seattle is 24 miles across a lake in a direct line, and nearly 40 miles by land. Seattle has now about 40,000 inhabitants, and is a manufacturing town with many miles of tramways. On the other hand coal of fair quality is very cheap, being about 5s. per ton in large lots.

Electricity Applied to Farm Work.—An interesting example of electricity as applied to farm work has been in operation for some time at Ardwell, Wigtownshire. The whole of the usual farm machinery—such as threshing, sawing, corn-crushing, and the like—is here driven by an electric motor. Power is generated by water, the turbo-dynamo being about a thousand yards from the farm. The current is conveyed underground to the house and farm, in each of which a storage battery is placed. The whole of the house is lit with the electric light, and an electric motor is provided for pumping water for domestic purposes. At the farm, which is also lit throughout with the electric light, there is a 16-H.P. motor, which is arranged to drive the farm machinery.

Telephone Wires.—On Monday last the representatives of the National Telephone Company and the Broughty Ferry Police Commission met in Dundee to consider the question of rent for wayleave for the Company's posts, a question raised by the Commissioners requesting payment of a fixed sum per annum per post, and also for each wire on the posts. The representatives of the Company offered (1) a rent of 1s. per pole, which means a sum of £2. 14s., there being 54 poles on the streets; (2) the continued free use of the instrument at the Police Chambers; (3) an instrument for the use of the Parochial Board at half-price; (4) two new call offices for the convenience of the public; and (5) a reduction of the three-penny tariff rate for conversation to Dundee to one penny. The Commissioners' representatives considered the terms offered quite inadequate for the privileges the Company enjoys, and told its representatives they had no hope of their Board agreeing to the Company's proposals, also giving them to understand that, unless more liberal terms were offered, the Company would have to remove their posts off the streets immediately after June 14th next.

The City and Guilds of London Institute and Technological Examinations.—A letter has been addressed to County Councils throughout the kingdom, and to the secretaries of technical schools in connection with the City and Guilds of London Institute with respect to the altered conditions consequent on the passing of the Local Taxation Act, under which the Institute's examinations will in future be conducted, and indicating the kind of assistance which the Institute will be prepared to give in the way of directing technical instruction, of examining the students of technical classes, and of awarding certificates and prizes. The Committee of the Institute have adopted a scheme, and are prepared to receive applications from County Councils or school committees for the inspection of classes in technical subjects, and also for special reports on the results of the examination of the students of separate classes registered under the Institute. The Committee propose to appoint two inspectors, one in connection with the engineering and allied trades, and another with the manufacture of textile fabrics; and they further propose to appoint a third inspector for industries involving applications of chemistry, and possibly others, as occasion may require.

Trade Classes at Finsbury.—The following paragraph, relating to the Finsbury Technical College trade classes, taken from

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the annual report of the Principal to the Governors of the Institute is instructive :—

The Trade Classes show a decrease of 33 students, the entries being 150, as compared with 183 last Session. The instructors of these classes have worked willingly and well, and have the success of their students thoroughly at heart. The falling off is not attributable to any want of earnestness on their part, but is due to several causes, chief of which are the insufficient public information given of the existence of these classes, and the competition of classes of a somewhat similar description in other institutions that advertise, not only in their own districts, but all over London. In view of the present movement for establishing technical institutes in various localities in London under the scheme of the Charity Commissioners, it is worth while to consider whether, under the circumstances attendant on our Trade Classes and the limited accommodation we are able to afford them, it would not be a decided advantage to these classes and to the persons attending them if they were handed over to some one of the proposed Technical Institutes, where better provision could be made for them than is possible under present circumstances, and where they might benefit from being associated with a Building Trades School held in the daytime. To sever from Finsbury these classes, which have existed since 1873, would be, no doubt, a loss to the College, but that our loss would be their gain cannot be doubted by anyone acquainted with the limitations which, under existing conditions, circumscribe their usefulness.

Thunderstorms.—On Saturday last the Newcastle-on-Tyne district was visited by severe thunderstorms, and a Mr. Robert Taylor was killed in the course of the afternoon by lightning at Harton. He was at the time engaged in holding a galvanised iron pipe, attached to a hose pipe, and was watering some clay. Portions of the deceased's clothing was found fifteen yards off. About half the clothing was torn away from the body, and the left boot was taken off. During the morning the nail manufactory of Mr. Galloway, at Gateshead, was struck by lightning and a chimney was partly demolished, three persons being injured. In the afternoon houses at Gateshead, Walker, and Gosforth were struck by lightning and damaged. At Medomsley, on the previous day, whilst a deputy over-man, named John Walton, was proceeding to his work at the Consett Iron Company's Derwent pit, he was struck by lightning as he was passing through the fields about 200 yards from the colliery. One of his shoes was taken off his foot and the other shoe was cut in several places. Part of his clothing was lying fully twenty-three yards from where he fell. Houses and cattle are reported as having been struck in the North, South, East, West, and Midlands. At Hartlip, in Kent, two labourers, who sought shelter from a storm under an elm tree, were injured by a discharge which stripped the bark off the tree.

Engineering at Cambridge.—The Syndicate appointed to make arrangements for the further development of the Cambridge Engineering School have reported to the Senate, and submitted plans for an engineering laboratory, prepared by Mr. W. C. Marshall, of the firm of Marshall and Vickers, architects. The Syndicate state that they were fortunate in securing the co-operation of a number of engineers and others interested in the development of an engineering laboratory in the University. A Committee was formed to invite subscriptions. The subscription list was opened by a gift of £1,000 from the Chancellor, and the total amount subscribed up to the present time is £4,847. 16s. Several important contributions of apparatus have also been made towards the equipment of the laboratory. A part of the sum collected has been spent in providing apparatus for immediate use, and about £4,100 remains available for building, or for the purpose of additional apparatus. With the establishment of a tripos in mechanical science (November 10, 1892) the work of the department has increased to such an extent that the existing accommodation is inadequate. There are now sixty-two pupils in attendance, most of whom are engaged on a systematic course of study in mechanical science. The Syndicate do not propose to carry out the plans at once in their entirety, but ask to be authorised to proceed with such portions of the work as they are able to execute with the funds at their disposal.

The Electrical Equipment of the McGill University.—We are indebted to Prof. Carus-Wilson for the following interesting particulars with regard to the electrical equipment of the Applied Science Buildings at the McGill University, Montreal. The buildings are lighted throughout by the electric light, the lighting station being an essential part of the Electric Engineering Laboratories. The plant consists of two 30-kilowatt dynamos, a Siemens and an Edison-Hopkinson, giving 105 volts at 460 revolutions. They are driven direct by two 60-H.P. Willans engines. The main switchboard is arranged so that the lighting may be carried out either on the three-wire or the two-wire system or by accumulators. The main circuits supply current to the Engineering and Physics Buildings, in which there are respectively 1,200 and 500 16-c.p. lamps. There are also six arc lamps, a 10-H.P. motor for working a lift, two 5-H.P. fan motors, and seven smaller motors driving lathes, &c. The currents in the various circuits are measured by the fall of potential along ½in. copper rods connected with the switchboard. A sliding commutator enables any one of nine circuits to be connected to a voltmeter which requires 30 millivolts for a full scale deflection. There are two scales, one reading to 400 and the other to 80 amperes. The voltmeter is also fitted with a similar sliding commutator for measuring voltage. The scales are transparent and illuminated from behind, enabling the indications to be read at a considerable distance off.

The London County Council and the Telephone Protection Clauses.—At the meeting of the London County Council last week the Parliamentary Committee reported as follows :—We understand that a Joint Committee of both Houses is to be appointed to consider the subject of electric traction. There have been several discussions before the Board of Trade and Committees of Parliament as to whether any, and, if so, what form of protection should be given to the Telephone Company in the case of Bills authorising use of electricity either for lighting purposes or for motive power. It appears to be admitted that telephone wires constructed and worked on the principle commonly followed by the National Telephone Company are liable to be interfered with by induction as a result of the use of electricity for other purposes in the neighbourhood. The Telephone Company claim in such cases a clause, which, while reserving their position, would place those using electricity for other purposes under considerable obligations in order to provide against possible induction. The decisions of the Board of Trade and of the Committees have varied, and the appointment of a Select Committee to consider the whole question has become necessary, and as the Council is interested in the matter in regard to electric lighting, and possibly may be hereafter in regard to tramways which it may be desired to work by electricity, we recommend that the Council do give instructions that it be represented before the Joint Committee. The recommendation was adopted.

The "Hodgkins Fund" Prizes.—In October, 1891, Mr. Thomas George Hodgkins, of Setauket, New York, made a donation to the Smithsonian Institution, the income from a part of which was to be devoted "to the increase and diffusion of more exact knowledge in regard to the nature and properties of atmospheric air in connection with the welfare of man." The Smithsonian Institution now announces the following prizes to be awarded if satisfactory papers be offered :—1. A prize of $10,000 for a treatise embodying some new and important discovery in regard to the nature or properties of atmospheric air. 2. A prize of $2,000 for the most satisfactory essay upon—(*a*) The known properties of atmospheric air considered in their relationships to research in every department of natural science, and the importance of a study of the atmosphere considered in view of these relationships; (*b*) The proper direction of future research in connection with the imperfections of our knowledge of atmospheric air, and of the connections of that knowledge with other sciences. 3. A prize of $1,000 for the best popular treatise upon atmospheric air, its properties and relationships (including those to hygiene, physical and mental). 4. A medal will be established, under the name of the Hodgkins Medal of the Smithsonian Institution, which will be awarded annually or biennially, for important contributions to our knowledge of the nature and properties of atmospheric air, or for practical applications of our existing knowledge of them to the welfare of mankind. The treatises may be written in English, French, German, or Italian, and should be sent to the secretary of the Smithsonian Institution, Washington, before July 1, 1894, except those in competition for the first prize, the sending of which may be delayed until December 31, 1894. It is probable that special grants of money may be made to specialists engaged in original investigation upon atmospheric air and its properties.

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ELECTROMAGNETIC THEORY.—L.

BY OLIVER HEAVISIDE.

(Continued from page 7.)

§ 200. In the consideration of the transmission of waves along wires, especially, of course, in practical calculations, it is more convenient to employ the line-integrals of the electric and magnetic forces as variables rather than these forces themselves. This transformation of variables involves other necessary transformations, and the connection between the old quantities, suitable for waves in general, and the new, should be thoroughly understood, if something more than a superficial knowledge of the subject be desired.

Thus, commencing with a circuit consisting of a pair of parallel straight conducting tubes, of no resistance in the first place, take for reference any plane which crosses the tubes perpendicularly. It is the plane of the wave at the place, and the lines of electric and magnetic force lie in it, the former starting from one (the positive) and ending upon the other (the negative) tube, the latter passing between and round them. These lines always cross one another perpendicularly, but their distribution in the plane may be varied by changing the size and form of section of the tubes by the plane and the distance of separation. Now there is no axial magnetic induction—that is, induction parallel to the tubes. Nor is there any tangential component of electric force on the surface of the tubes. It follows, by the second circuital law, that the line-integral of the electric force from one tube to the other is the same by any path in the reference plane. It is not the same by any path with the same terminations if we depart from the reference plane, but that is not yet in question. Call this constant line-integral V. It is the transverse voltage. In another form we may say that the circuitation of the electric force in the reference plane is zero.

Next consider the magnetic force. Its circuitation is also zero in the reference plane, provided the one tube or the other is *not* embraced, because there is no axial electric current in the dielectric. But when a tube is embraced the circuitation is finite. Call this quantity C. It is "the current" in the tubes, or, at any rate, is the measure thereof, and is positive for one tube and negative for the other. These two quantities, V and C, the transverse voltage and the current, are the new variables. They are as definite as **E** and **H** themselves in a given part of the reference plane under the circumstances.

Next, as regards the fluxes, displacement and induction. Introduce a second reference plane parallel to the first and at unit distance in advance of it along the tubes. Anywhere between the planes we have $\mathbf{D}=c\mathbf{E}$, where **E** and **D** vary according to position. Now, as we substitute the complete voltage for **E**, so we should substitute the complete displacement for **D**. The complete displacement is the whole amount leaving the positive and ending upon the negative tube, between the reference planes. That is, it is the "charge" per unit length of the tubes, say Q. As **D** is a constant multiple of **E**, so is Q a constant multiple of V. Say $Q=SV$. This S is the permittance of the dielectric, per unit length axially. It is proportional to c, the permittivity, but of course involves the geometrical data (brought in by the tubes) as well.

Similarly, we have $\mathbf{B}=\mu\mathbf{H}$ everywhere between the reference planes, **H** and **B** varying from place to place. But if we substitute the complete circuitation of **H**, we should also substitute the complete integral of **B**. This means the total flux of induction passing between and round the tubes, between the reference planes. Call it P. It is the magnetic momentum per unit length axially. As **B** is a constant multiple of **H**, so is P a constant multiple of C. Thus $P=LC$, where L is the inductance per unit length axially. This L varies as the inductivity μ, and involves the geometrical data.

In virtue of the relation $\mu cv^2=1$, the inductance and permittance are reciprocally related. Thus, $LSv^2=1$. Since v is constant, it might appear that the inductance was merely the reciprocal of the permittance, or the elastance, with a constant multiplier, only to be changed when the dielectric is changed. But there is much more in it than this. Different physical ideas and effects are conditioned by inductance and permittance. Inductance and inductivity involve inertia, whilst permittance and permittivity involve compliancy or elastic yielding.

Observe that P and Q are analogous, being the total magnetic and electric fluxes, whilst V and C are also analogous, the voltage and gaussage respectively. So the ratios L and S are also strictly analogous, in spite of their quantitative reciprocality. They are both made up similarly to conductance, only in the case of permittance it is reckoned across the dielectric from tube to tube, and in the case of inductance round and between the tubes—that is, the magnetic circuit is closed, and the electric circuit unclosed. There are other ways of setting out the connections, but the above way brings out the analogies between the electric and magnetic sides in a complete manner. The quantity C may be quite differently regarded when the magnetic field penetrates into the substance of a tube (then to be of finite conductance), viz., as the total flux of conduction current, or sometimes of displacement current as well, in a tube. But the above method is independent of the penetration, holding good whether there is penetration or not, saving small corrections due to the waves not being quite plane. The magnetic view of C, as the gaussage, is also the nearest to experimental electrical knowledge. The other view is darker, because we cannot really go inside metals and observe what is going on there, or the forces in action. They must be inferential in a greater degree than the external actions.

The electric energy per unit volume being $\frac{1}{2}\mathbf{ED}$ or $\frac{1}{2}cE^2$, when this is summed up throughout the whole slice of the medium contained between the reference planes at unit distance apart, we obtain the amount $\frac{1}{2}VQ$ or $\frac{1}{2}SV^2$, which is a therefore the electric energy per unit of length axially.

Similarly, the magnetic energy density $\frac{1}{2}\mathbf{HB}$ or $\frac{1}{2}\mu H^2$, when summed up throughout the slice, amounts to $\frac{1}{2}CP$ or $\frac{1}{2}LC^2$. The reader should, in all these transformations, compare the transformed expressions with the original, and note the proper correspondences. It is all in rational units of course, to avoid that unmitigated nuisance, the 4π factor of the present B.A. units.

The density of the flux of energy, which is the vector product of **E** and **H** in general, is of amount simply EH when the forces are perpendicular, as at present. When this is summed up over the reference plane, the result is VC, the product of the voltage and current. The flux of energy is parallel to the guiding tubes, and EH is the amount for a tube in the dielectric of unit section, whilst VC is the total flux of energy.

The relation $E=\mu vH$, or, which means the same, $H=cvE$, which obtains in a pure electromagnetic wave, becomes converted to $V=LvC$, or $C=SvV$. We see that Lv is of the dimensions of electric resistance, and Sv of electric conductance. Similarly, because V and C are the line-integrals of **E** and **H**, we see that μv is of the dimensions of resistance, and cv of conductance. The activity product VC is what engineers have a good deal to do with, now that "electrical energy," or energy which has been conveyed by electromagnetic means, is a marketable commodity. However mysterious energy (and its flux) may be in some of its theoretical aspects, there must be something in it, because it is convertible into dollars, the ultimate official measure of value.

§ 201. Now, still under the limitation that the guiding tubes have no resistance, and that the dielectric has no conductance, consider the special forms assumed by the circuital laws. These are, in general,

$$\text{curl}\,\mathbf{H}=c\dot{\mathbf{E}}, \quad \ldots\ldots\ldots \quad (1)$$

$$-\text{curl}\,\mathbf{E}=\mu\dot{\mathbf{H}}. \quad \ldots\ldots\ldots \quad (2)$$

Now, in applying these to our plane waves, we may observe at the beginning that **E** and **H** and their time-variations are in the reference plane, and have no axial components. So the only variations concerned in the operator "curl" are such as occur axially, or parallel to the guides. Let x be distance along them, then the circuital laws become

$$-\frac{d\mathrm{H}}{dx}=c\dot{\mathrm{E}}, \quad \ldots\ldots\ldots \quad (3)$$

$$-\frac{d\mathrm{E}}{dx}=\mu\dot{\mathrm{H}}, \quad \ldots\ldots\ldots \quad (4)$$

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which apply anywhere in the reference plane. Transforming to V and C, we obtain

$$-\frac{dC}{dx}=S\dot{V}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$-\frac{dV}{dx}=L\dot{C}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

By (3) and (4) we see that the space-variation of H is the electric-current density, and the space-variation of E the magnetic-current density in the dielectric. By (5) and (6) we express the same truths for the totals concerned.

We may see the meaning of (5) thus. Draw a closed line in the reference plane on and embracing the positive guiding tube. The circuitation of **H** there is the total surface current C. Let the closed line be shifted to the next reference plane at unit distance forward. Then $-dC/dx$ is the amount by which C decreases during the shift, and (5) tells us that it is equivalently represented by the time-rate of increase of the charge on the tube between the reference planes, or the rate of increase of the total displacement outward. This process may be applied to any closed line in the reference plane, provided it embraces the tube. When it is shifted bodily forward through unit distance to the next reference plane, the amount by which the circuitation of **H**, that is, C, decreases from the first to the second position measures the displacement current through the strip of the cylinder swept out by the closed line. This is the time-rate of increase of the charge per unit length of the tubes, and is the total transverse current from one tube to the other.

The meaning of (6) requires a somewhat different, though analogous, elucidation. Join the tubes by any line in the first reference plane. The line integral of **E** along it is V, the transverse voltage. Shift the line bodily along the tubes to the next reference plane. The transverse voltage becomes $V+dV/dx$, still reckoned from the positive tube to the negative. But if we join the two starting points on the positive tube together, and likewise the ending points on the negative tube, we make a complete circuit, having two transverse sides and two axial sides. Now reckon up the voltage in this circuit. The axial portions contribute nothing, because the electric force is perpendicular to them. The voltage required is, therefore, simply the difference in the values of the transverse voltage in the other two sides, or dV/dx. By the second circuital law, it is also measured by the rate of decrease of induction through the circuit, that is, by $-L\dot{C}$. Whence follows equation (6).

The reader who is acquainted with the (at present) more "classical" method of treating the electromagnetic field in terms of the vector and scalar potentials cannot fail to be impressed by the difference of procedure and of ideas involved. In the present method we are, from first to last, in contact with those quantities which are believed to have physical significance, instead of with mathematical functions of an essentially indeterminate nature, and also with the laws connecting them in their simplest form. Notice that V is not the difference of potential in general. It sometimes degenerates to difference of potential, viz., in a perfectly steady state. But when the state changes, we cannot express matters in terms of an electric potential.

Now, still keeping the guiding tubes perfectly conducting, let the medium in which they are immersed be slightly conducting. The electric-current density, which was $c\dot{\mathbf{E}}$ before, now becomes $k\mathbf{E}+c\dot{\mathbf{E}}$, where the additional $k\mathbf{E}$ is the conduction-current density. Along with this there is waste of energy at the rate kE^2 per unit volume. This waste of energy may also be regarded as a storage of energy, viz., as heat in the medium. But as it is not recoverable by the same means (reversed) which stored it, it is virtually wasted, and we have no further concern with it.

We have next to consider the total waste in the slice of the medium between the two reference planes, in terms of the transverse voltage. It sums up to KV^2, where K is the transverse conductance of the medium per unit length axially. This is proportional to the conductivity k, and involves geometrical data in the same way as the transverse permittance, as may be readily seen without symbolical proof, on considering that the conduction-currrent lines and the displacement lines are similarly distributed, whilst both are controlled by the transverse voltage. In fact, the conduction-current density $k\mathbf{E}$ sums up to KV, the complete transverse conduction-current, in the same way as the displacement density $c\mathbf{E}$ sums up to the total transverse displacement SV, in terms of the permittance and voltage.

The first circuital law (1) becomes changed to

$$\text{curl}\,\mathbf{H}=k\mathbf{E}+c\dot{\mathbf{E}}, \quad . \quad . \quad . \quad . \quad . \quad (7)$$

by the addition of the conduction current. And its modified form (3) for our plane waves becomes

$$-\frac{dH}{dx}=kE+c\dot{E}; \quad . \quad . \quad . \quad . \quad . \quad (8)$$

whilst in terms of the new variables, voltage and gaussage, we have this extended form of the equation (5),

$$-\frac{dC}{dx}=KV+S\dot{V}. \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Next, let the medium become magnetically conductive as well, no other change being made. The conduction-current density is $g\mathbf{H}$, and its distribution resembles that of the induction itself, whilst its amount is controlled by the quantity C, the gaussage. The total magnetic-conduction current may therefore, be represented by RC, where R is the magnetic conductance, which varies as the magnetic conductivity g, and involves the geometrical data in the same manner as the inductance does.

Similarly, the rate of waste of energy due to the magnetic conductivity is gH^2 per unit volume, and the total rate of waste in the slice of the medium between the two reference planes amounts to RC^2 correspondingly.

Finally, the effect of the magnetic conductivity is to turn the second circuital law from the elementary form (2) to

$$-\text{curl}\,\mathbf{E}=g\mathbf{H}+\mu\dot{\mathbf{H}}, \quad . \quad . \quad . \quad . \quad (10)$$

and, correspondingly, the special form (4) for our plane waves becomes turned to

$$-\frac{dE}{dx}=gH+\mu\dot{H}. \quad . \quad . \quad . \quad . \quad . \quad (11)$$

This, in terms of V and C, is equivalent to

$$-\frac{dV}{dx}=RC+L\dot{C}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

which is the proper companion to the equation (9) expressing the first circuital law. These equations (9) and (12) are the practical working equations.

We have already remarked that the structure of the electric permittance and conductance are similar. From this it follows that the time-constant c/k is identically represented by S/K. Similarly, the time-constant μ/g is identical with L/R.

The density of the flux of energy is with the two conductivities, still represented by the vector product of **E** and **H**, and therefore the total flux is still the activity product VC. To corroborate this statement, and at the same time show the dynamical consistency of the system, consider that if the quantity VC is really the flux of energy across a reference plane, the excess of its value at one plane over that at a second plane further on at the same moment represents the rate of storage of energy between the planes. Therefore, the rate of decrease of VC with x is the rate of storage between two reference planes at unit distance apart. Now,

$$-\frac{d}{dx}(VC)=-V\frac{dC}{dx}-C\frac{dV}{dx}, \quad . \quad . \quad . \quad . \quad (13)$$

On the right side use the circuital equations (9) and (12), and it becomes

$$V(KV+S\dot{V})+C(RC+L\dot{C}), \quad . \quad . \quad (14)$$

or, which is the same,

$$KV^2+RC^2+\frac{d}{dt}(\tfrac{1}{2}SV^2+\tfrac{1}{2}LC^2) \quad . \quad . \quad (15)$$

By the previous, the first term is the total electric waste, the second is the total magnetic waste, the third is the increase of

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total electric energy, and the fourth is the increase of total magnetic energy, per unit of time, between the two reference planes. This proves our proposition, with a reservation to be understood concerning the circuital indeterminateness of the flux of energy. There is, therefore, no indistinctness anywhere, or inconsistency. We have now to show in what manner the above is affected by the resistance, &c., of the guides.

(To be continued.)

THE CHICAGO EXHIBITION INTRAMURAL ELECTRIC RAILWAY.

We take the following interesting particulars with regard to the elevated electric railway in the Exhibition grounds at Chicago from a long and well-illustrated account appearing in the *Electrical World* of May 6th :—

The Western Dummy Railroad Company, says our contemporary, obtained the contract on a basis of 25 per cent. of the gross receipts and a 10 cent. fare.

The line consists of close on three miles of double track. There are ten stations in all, and at each of these, with a few exceptions, the track is caused to rise, thus serving as a check to approaching trains and an assistance to those departing. Otherwise the track is essentially level, varying from that to 0·42 per cent and 1·5 per cent. grades, and in one short stretch reaching 2 per cent. The curves at the terminals are short, viz., 100ft. radius, and the others vary between that and 2,000ft.

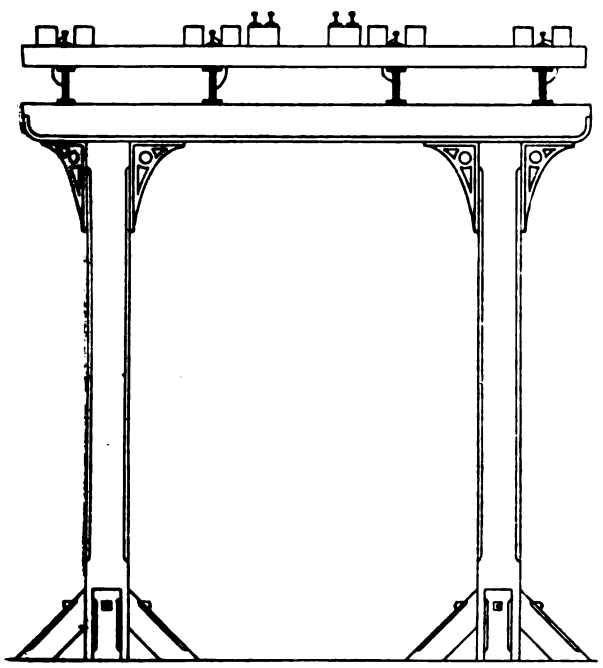

Fig. 1.—Section of Track, showing Electrical Connections.

Work was commenced early last autumn on the elevated structure, which is a doubled-tracked affair, supported for the most part by the 12 × 12 square sets of pine, and surmounted by I beams—two to the track. These latter are usually 25ft. in length, and are carefully bonded to furnish the main return for the current (*see* Fig. 1). This bonding consists of from two to five copper strips, according to the situation, each 2in. wide and $\frac{1}{16}$in. thick, riveted cold through holes in the web of the stringers that have been carefully reamed to afford good electrical contact. These rivets are of copper, $\frac{7}{8}$in. in diameter and 2in. long, and two of them are used in each bond. The outer strip of each bond is looped into an eye for the ready reception of the terminal of a conductor connecting with the track above. The conductors that are used for carrying the current to the motor cars are T rails of exactly similar design and weight (60lb. to the yard) as the track rails. They are laid parallel to the tracks, 18in. to one side and elevated so that their faces are about 12in. above the crossties. The wooden blocks supporting the working conductors serve as insulators. Parallel to the working conductor, and as close to it as possible, is another rail similarly elevated on blocks. This is the feeder, and extends along both trolley rails for about three-fifths of the distance from the power-house to the further terminus. These two lines of rails—the working conductor and the feeder—are laid so that their joints come together, and are bonded in similar manner to the track rails with the loops or eyes facing each other, and connection is made between the two by inserting into these eyes the two legs of a hairpin-shaped wire, and electrical connection insured

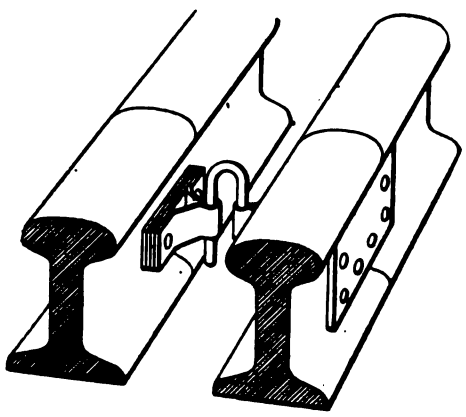

Fig. 2.—Feeder and Working Rail Connection.

by soldering (Fig. 2). The track rails are also bonded in similar manner, and each rail of each track is connected to the girder beneath by a wire which is soldered into this eye. Thus the four large girders form the electrical return for the current which passes from the wheels to the track.

The equipment consists of 15 trains of three open trailers and a motor car, together with three extra motor cars. Each of these cars is 50ft. in length. The trailers when loaded will weigh 22 tons and the motor cars 30 tons. Each motor car is equipped with four motors, one to each axle. These were specially built for the purpose by the General Electric Company, and are of the T.-H. 4-pole ironclad type. The armatures are Gramme ring with bar winding with three turns to

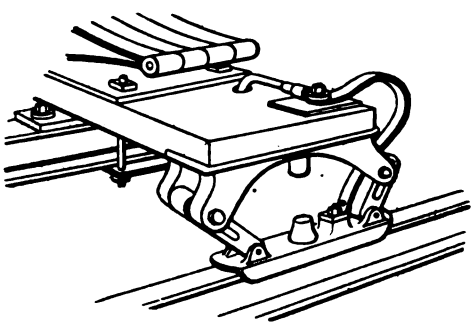

Fig. 3.—The Trolley.

the coil, and are cross-connected so as to require but two brushes—carbon being used. They are single reduction, so geared as to work at a maximum speed of 35 miles per hour, and are capable of an output of 133 H.P. with safety—thus giving a total capacity for each motor car of something over 500 H.P. The motors themselves weigh about 4,000lb.

On each motor car there are four trolleys or sliding contacts —two on each side. These are attached each to a heavy oak plank extending out from the centre of the trucks some 18in. beyond the wheels. They consist (*see* Fig. 3) of an iron frame with two arms, as shown in the cut, having pins which loosely hold two iron links, to which is attached the shoe proper. This is of cast iron, about 12in. long, and so shaped as to fit loosely upon the face of the rail. All of this portion of the trolley is carefully insulated from the truck, but electrical connection is made between the shoe and a binding post on top of the wooden support by means of a bundle of flexible copper strips. The

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link connection permits of considerable vertical movement of the shoe, and also of the adjustment of the latter to the motion of the car in either a forward or backward direction. The first shoes made were of brass, and were cast with a lug on their upper side corresponding with another one on the iron support above. These were intended to form supports for a spiral spring in compression for the purpose of insuring better contact between the shoe and the track. Experiment, however, has shown that the weight of the shoe is sufficient for this purpose, and the spring has been discarded. Iron has also been substituted for brass as being cheaper and answering equally well.

The controlling appliances are located at the front end of the car in a compartment set aside for this purpose, the motive power of the regulating drums being compressed air. All the trains are fitted with air-brakes.

The power house consists of a boiler room 140ft. long and 60ft. wide, and an engine and dynamo room 140ft. by 87ft. In the former is located the bank of Babcock and Wilcox boilers, ten in number, rated at 300 H.P. each. These are fired by oil supplied through jets extending into the combustion chamber, fed by 2in. pipes connected with the tanks at the south boundary to the park. On the engine-room floor, which is raised some 10ft. above the boiler-room floor, are arranged, beginning at the east end, a Reynolds tandem compound Corliss engine, coupled to a direct 500-kilowatt multipolar generator. The armature of this machine overhangs the bearing of the shaft. Next comes a Hammond-Williams vertical engine, cross compound, driving a similar generator 500-kilowatt capacity, and capable of working up to 1,200 H.P. In the centre of the floor is the great 2,000-H.P. cross-compound Reynolds-Corliss engine, which operates a 1,500-kilowatt multipolar generator. This is direct connected. West of this stands a McIntosh and Seymour tandem compound engine, coupled direct to a 200-kilowatt multipolar generator, and at the west end of the building is located a tandem compound Greene engine, belted direct to a 500-kilowatt multipolar generator.

The great 2,000-H.P. generator, which is fairly entitled to the place of honour which it occupies in the centre of the building on account of its size, has another claim upon our attention from the manner of its construction. On account of its size, the different parts of which it is composed, after having been shaped at the various shops and foundries in which they were made, were shipped separately and put together for the first time in this building. The estimated weights of the parts are:—

	Tons.	cwt.
Weight of field magnet complete	35	14
Weight of armature	32	17
Weight of commutator	5	10
Total weight of dynamo	80	7

Some of the dimensions are as follows:—

Diameter of armature	10ft. 6in.
Face of armature	36¾in.
Diameter of commutator	7ft. 6in.

On account of the great difference between the internal and external diameters of the hub of the armature it was necessary to take precautions against fracture or warping due to shrinkage. The method employed was as follows:—The hub was cast with three slots at an angle of 120deg. with each other, extending radially so as to allow for a maximum contraction as the casting cooled. When all was cool these slots were filled with molten iron, thus making the hub solid, and a steel ring 7in. broad by 4in. deep was then shrunk on to a seat prepared for it, immediately surrounding the inner terminals of the slots.

The hub and shaft were shipped in one piece, and weighed, when received, 56 tons. The shaft itself is 25ft. long between centres, and 24in. in diameter. Its main bearing is 22in. in diameter and 42in. long. The hub, which was shrunk on to the shaft, supports at the end of its six heavy spokes a rim upon which are set 29 bars parallel to the shaft, each grooved longitudinally with a dovetailed slot, into which fit similar projections stamped into the inner edge of the sheets of sheet iron of which the armature core is built.

The armature core was built up of ordinary sheet iron 0·017in. thick, cut with lugs on the inner side for the slots before mentioned, and of such a length that nine of these sheets, set end to end, complete the circle and lap over just one-half a length. Each sheet has two dovetails on its inner side just corresponding in distance apart with the distance between the slots into which they are to slide. Thus, when the ninth segment is placed in position, the dovetail in its lapping portion takes into the same slot as the first dovetail of the first segment. Additional segments are added, with their shorter sides abutting, the segments of each circle lapping the joints in the preceding circle, and thus the armature core is built up spirally. The dovetails of each segment are introduced into the slots at one end, and the sheet is pushed along until in place. When a thickness of 3in. has been thus built up, a brass section 1in. thick with radial openings is slipped on, and the completed portion of the core tightly compressed. In this case, a large number of small hydraulic jacks were employed to force the sheets of iron into intimate contact. The brass plates are allowed to remain in position, the radial openings answering for ventilating ducts. Upon this another section is built in similar manner, and so on, until the required number of sections are completed. There are in this armature nine of these sections and eight ventilating sections, and 17,200 pieces of sheet iron, weighing 25 tons, were used in its construction. Next, the washers are put on. These consist of two large cast iron rings weighing four tons each, which have a lesser outside and inside diameter than the armature ring itself, and they are tied together by 29 tie-bolts 1½in. in diameter, by tightening the nuts on which the layers of sheet iron are strongly compressed. The tie-rods pass under the armature ring, but are not otherwise insulated from the armature core. In this armature the coils are not wound over the ring, but are embedded in the iron itself. For this purpose, the sheet iron, before it was sent to Chicago, had been stamped with slots near its outer circumference, so spaced relatively to the dovetails on each sheet that when they are placed in position the slots on succeeding layers register exactly. There are 348 of these slots. When first pressed together the edges of the sheet iron gave the interior surfaces of these slots a somewhat rough appearance. This had to be smoothed down, and for this purpose the file was brought into play. A 4-kilowatt Edison motor was belted to four filing machines, which consisted simply of four long files of the proper length and size, which were inserted in as many slots and given a reciprocrcating motion by means of cranks. All of these 348 slots have thus been filed smooth, and the face of the armature was also filed down by hand.

Each coil consists of two turns, each consisting of two copper strips in multiple. These strips are ¾in. wide by ¼in. thick, and are carefully insulated from each other by mica, and then wrapped together in mica and oiled linen tape. Before inserting these in the slots, channel-shaped tubes of mica were placed in the slots as a further insulation between the conductors and the core, and then the two compound conductors were introduced, radially to each other, and, finally, outside of these strips of wood were tightly driven in, fixing the conductors rigidly in place.

The equipment and operation of this road, says the *Electrical World*, has a much greater significance than its mere size would indicate, for it is practically the first electrical equipment of an elevated road that has ever been made.

ON THE DISSIPATION OF ELECTRICITY BY DIFFUSED LIGHT AND IN THE DARK.*

BY EDOUARD BRANLY.

My previous experiments on the dissipation of electricity, some of which have been published in the *Comptes Rendus*, having led me to think that the conductivity of gases and especially of atmospheric air depended less on their individual properties than on the conducting surfaces between which they were interposed, I sought for fresh proofs. I wish in the present communication to call attention to the definite facts, out of many experiments the interpretation of which is still doubtful, which seem to me to be of special interest. The observations were made with a gold-lea

* From the *Comptes Rendus*, Vol. CXVI., No. 15.

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electroscope, the insulated rod of which is screwed on to the block of a pneumatic machine. Upon this block are placed as desired the bell-jars or the conducting boxes. The gold-leaf is enclosed in a completely metallic cage. The insulating material I use is roll sulphur, which is easy to work and possesses, in addition to exceptional insulating qualities, the advantage of being proof against atmospheric influences, thus rendering unnecessary the taking of special precautions. In order to obtain a constant charge, I employ two-fluid cells (platinum, sulphate-protoxide of mercury, zinc, sulphate of zinc) which I described in *La Lumière Electrique* of May 16, 1891. The cells are divided into groups of 25, most of which have been in use several years.

Dissipation of the Negative Charge on Aluminium placed in Diffused Light.

A disc of aluminium, 15cms. in diameter, was placed on the knob of the electroscope in a well-lighted room, and was connected to the negative pole of a battery of 300 cells. A well-polished disc, if it has been polished several days previous, behaves like any other metal, polished or unpolished. It shows a loss of charge, sensibly equal for the two signs, very slow and independent of the light. But if the disc of aluminium has been energetically and freshly polished (polished by turns with emery paper and a drop of essence of turpentine), the fall of the gold leaf becomes rapid even under diffused light. The total separation of the gold leaves being 80 divisions on the micrometer of the inspecting microscope, the fall in 30 seconds may amount to half this, that is to say, 40 or even 45 divisions out of 80. The discharge is soon complete. The active light was, in this case, the light which had traversed the windows of the laboratory. A glass vessel, even if tinted an orange yellow, may be placed on the supporting block and cover the disc without causing the discharge to cease ; it is only slowed down. It follows from this that the most refrangible rays are not the only active ones. The dissipation decreases the further one goes from the time when the disc was polished.

The following are a few figures relating to two consecutive tests, the observed fall of the gold leaf being expressed in micrometer divisions (total separation = 80 divisions).

Freshly polished aluminium disc.	Fall in 60 seconds.
Under the yellow glass vessel	4
In the open	25
Under the yellow glass vessel	3
In the open	21
,, ,, ,, (after 35 minutes)	9

The same disc was then repolished with the same care as before, and its sensitiveness was increased. Generally speaking, it increased to a certain limit, after which more polishing had no effect.

	Fall in 30 seconds.
In the open	27
Under yellow glass	3
In the open (after 35 minutes under glass)	8

When the disc is covered by a metallic net with very small meshes, a loss due to the light that traverses these meshes is very clearly traceable. Perfectly-polished zinc in diffused light showed a loss equal to 15 micrometer divisions in 30 seconds (aluminium exceeding 45). A freshly-polished aluminium disc exposed to a blue sky through an open window, but sheltered from the direct solar rays, lost all its charge in seven seconds ; the zinc disc required 20 seconds, and one of cadmium 75 seconds. The discharge was naturally still more rapid under the direct action of the sun's rays. It also occurred with the light from the clouds.

When a disc of aluminium connected to the earth, freshly polished and illuminated by daylight, is placed in front of the knob of a *positively* charged electroscope, the electroscope is rapidly discharged. Copper, tin, brass cause insignificant losses.

Dissipation of both Positive and Negative Charges on Bismuth ed in the Dark.

As I have already pointed out, metals, whether polished or not, exhibit in the dark and in the open a small loss of charge independent of that caused by light, and which is shown on the electroscope previously used by a fall of one to two divisions in ten or fifteen minutes. When the discs are covered with a metallic box the loss of charge is almost zero for the same interval of time.

A disc of bismuth 15cms. in diameter, covered with a metallic box and charged positively or negatively, showed a constant loss of 12 micrometer divisions in ten minutes, in dry or wet air, and whatever the age or degree of polish. Bismuth is the only metal with which I have observed this noteworthy loss in the dark. I should add that out of the five bismuth discs I possess only two exhibit this phenomenon. However, whatever may be the investigations that it will be necessary to carry out before we can know the cause of this peculiarity, the existence of the special influence of the nature of the surface upon the dissipation of electricity even in the dark is made manifest.

THERMAL RADIATION IN ABSOLUTE MEASURE.*

BY J. T. BOTTOMLEY, F.R.S.

The Paper contains an account of an experimental investigation by the author in continuation of researches on the same subject which have been already published (Roy. Soc. *Proc.*, 1884, and *Phil. Trans.*, 1887). In the earlier experiments metal wires heated by an electric current were used. The loss of heat from a heated body, however, depends to some extent on the form and dimensions of the body, and it seemed important to experiment on the loss of heat from bodies differing in form from the wires already used, and larger in dimensions. Accordindgly, two copper globes used by Mr. D. Macfarlane in 1872 (Roy. Soc. *Proc.*, 1872, p. 93) were employed for a new series of experiments.

After preliminary experiments (using the same enclosure which Macfarlane employed, and with the surfaces of Macfarlane's globes prepared in four different ways) new apparatus was constructed, the object being to experiment both with full air pressure and with different amounts of exhaustion of the air, and Macfarlane's enclosure being unsuitable for this purpose.

In the arrangement adopted, the heated globes were hung at the centre of a hollow metallic sphere, which was connected with the Sprengel pump and surrounded with cold water, and were allowed to cool. The temperature of the cooling globe was read off at equal intervals of time by means of a thermo-electric junction ; and from these readings the absolute loss of heat per unit of cooling surface, per unit difference of temperatures of surface and surroundings per unit of time is calculated.

The details of the apparatus and method of experimenting are given in the Paper. It is enough to say here that the globes were used with their surfaces in two different conditions :—(1) Thinly coated with lamp-black, and (2) silvered and brightly polished ; and in both conditions the absolute loss of heat, both in air and in vacuum, more or less complete, was determined. The tables and curves attached to the Paper give the details of the results.

To quote one or two examples :—With the sooted surface a total loss of heat by convection and radiation of $3{\cdot}42 \times 10^{-4}$ C.G.S. units per square centimetre, per second, per 1°C. of difference of temperatures of globe and surroundings, was observed with a difference of temperatures of 100°C., and with the surroundings at about 14°C. Under similar circumstances the radiation in vacuum of $\frac{1}{2}$M (half-a-millionth of atmospheric pressure of non-collapsible gas) was about $1{\cdot}40 \times 10^{-4}$.

Taking a silvered and brightly-polished surface under the same circumstances, the loss in full air was $2{\cdot}30 \times 10^{-4}$ C.G.S. ; and with the highest vacuum and brightest polish obtained, it was reduced $1{\cdot}80 \times 10^{-5}$ with in this case a difference of temperatures of 180°C. The loss with 100°C. difference would be considerably less, but is not known experimentally at present.

The author returns thanks to Mr. James H. Gray, M.A., B.Sc., for excellent assistance given ; and expresses himself most deeply indebted, both for assistance in experimenting and calculating of the results, and for most valuable and ingenious aid of various kinds during the course of this work, to his friend, Mr. A. Tanakadate, now Professor in Tokio, Japan.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, May 26th.

PHYSICAL SOCIETY.

5 p.m. Ordinary Meeting. Papers to be read and discussed : (1) Discussion upon Dr. Lodge's Paper—"The Foundations of Dynamics" ; (2) "A New Photometer," by A. P. Trotter ; (3) "Notes on Photometry," by Prof. S. P. Thompson, F.R.S. ; (4) "Exhibition of a Vibrating Bar," by C. J. Woodward.

MONDAY, May 29th.

UNIVERSITY COLLEGE, LONDON.

3:30 p.m. Opening of the new Engineering and Electrical Laboratories by the Duke of Connaught, K.G.

TUESDAY, May 30th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Annual General Meeting of corporate members only, to receive the Report of the Council, and to elect the Council and Auditors for the ensuing year.

THURSDAY, June 1st.

CHEMICAL SOCIETY.

8 p.m. Ordinary Meeting. Papers to be read.

FRIDAY, June 2nd.

ROYAL INSTITUTION.

9 p.m. Evening Discourse : "Study of Fluid Motion by means of Coloured Bands," by Prof. Osborne Reynolds, F.R.S.

* Abstract of Paper read before the Royal Society.

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(The Oldest Electrical Journal.)

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.

Editorial, Publishing, and Printing Offices :

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.

Telephone No. 2714. Telegrams: "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street. London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed "Coutts and Co."*

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All letters intended for insertion in "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as evidence of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. It is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices.*

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ELECTROLYTIC METERS.

Notwithstanding the fact that the voltametric is the most direct method of metering current, it is more usual, for commercial purposes, to employ some form of instrument constructed either on the principle that electromagnetic forces quicken or slow the time of a clock, or retard the motion of an electromotor by forces proportional to its velocity, such forces being fluid friction when the motion is very slow and the resistance due to Foucault currents. Now, as these electromagnetic meters must themselves be calibrated by means of a voltameter, it seems strange, at first sight, that electro-chemical devices are not more largely employed. There are many methods which appear in the laboratory to possess the elements of a decided commercial success, but, nevertheless, hang fire when they cross the threshold of the testing-room. It does not by any means follow that these methods are too delicate for every-day use, or that they require an undue amount of skilled attention. As often as not, their field of commercial utility is restricted by reason of the very different aspect certain little precautions or attentions come to wear when they are needed, not by one or two experimental apparatus situated in a laboratory and tended by a cohort of energetic students, but by several hundreds of pieces of mechanism placed here, there and everywhere, and exposed to wide variations of temperature and no little rough usage. It is, therefore, desirable to discover whether the small commercial favour with which voltameters have met is due to prejudice, or to inherent defects in electro-chemical methods of measurement when subjected to the exacting conditions of ordinary use.

The early form of voltameter, in which the amount of oxygen or hydrogen, or of the mixed gases given off on the passage of the current through an acidified solution, is taken as a measure of the energy expended, is obviously unsuited to

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practical requirements. A large current is required to produce any visible decomposition in a reasonable time; both the temperature and the pressure must be known accurately before the watts can be calculated; and, further, McLeod and others have shown that the theoretical amount of oxygen is not given off, the loss being a variable quantity. These drawbacks, however, do not prevent the use of modified forms of the instrument in German laboratories for electrolytic purposes. Another disadvantage is that, since the amount of chemical action produced in a given time by a certain current is independent of the shape or size of the instrument, it is impossible to increase its sensibility. On the other hand, this disadvantage is not of importance when we deal with the large currents now use industrially. In the Edison meter, invented first by J. T. Sprague, but brought out by Edison, the depositing cell is put as a shunt on the main current, and, in its early form, a continuous current passing between two balanced plates suspended in a solution of copper sulphate decomposed one plate and deposited copper on the other, causing it to gain in weight and tip over the balanced beam. This action registered a unit on a counting mechanism, and reversed the direction of the current, so that the lighter plate received the deposit. In practice it was found that the make and break, as necessitated by the reversals of the current, led to endless trouble, and the ingenious method of counting had to be abandoned. In the improved meter zinc is the metal employed and sulphate of zinc the solution. The current always goes in one direction, and fresh plates are inserted as they wear away. Theoretically this meter is not accurate, because the relation between the total current and that which has passed through the meter can never be known accurately, but in practice it has given satisfaction. MM. Desruelles and Chauvin have recently brought out a modification of the original Edison meter, in which the whole of the current passes through the instrument instead of only a portion. In the Grassot meter the anode is a silver wire, while the cathode is zinc and the solution nitrate of silver. As the anode loses weight the cathode descends and pulls round a drum actuating a train of clock-wheels and indicating dials. So much for electrolytic meters, proposed, and in use.

Turning now to the work which has been done in laboratories, we find that for purposes of accurate standardisation T. Gray recommends the silver nitrate voltameter used by Kohlrausch, Lord Rayleigh, and Mrs. Sidgwick, but prefers very thin vertical parallel plates to the bowl method recommended by Poggendorff and adopted by the latter. For large currents of from 10 to 100 amperes the use of a silver voltameter is prohibited by the expense, and Gray found that although, as stated by Lord Rayleigh and Dr. Gore, care had to be taken in drying the cathodes, owing to the tendency of the copper to oxidise in the air and to the cathode losing weight if left standing in the liquid, the error need never exceed one-tenth per cent. He recommended the use of anodes having a surface of 50 sq. cm. per ampere, and found that if the current density at the anode exceeded $\frac{1}{40}$ ampere per square centimetre the current was apt to be variable and might almost stop completely even when an electromotive force of 25 volts was used. This phenomenon depended on the density of the solution and the current, and in some cases, after a few minutes' cessation, the current nearly regained its former value, gases being freely given off. Gray also found that the temperature had a very marked effect on the weight of copper deposited, although the temperatures which would ordinarily be experienced in this climate had not. In his first Paper he recommended the use of ordinary pure copper sulphate, or that with only the addition of a trace of free acid; in his second Paper the addition of 1 per cent. of sulphuric acid was recommended. J. Vanni, repeating Gray's experiments, confirmed his results as regards the effect of the size of the anode, and recommended the use of a copper sulphate solution containing merely a trace of free acid; and Oettel, as we noted in our last issue, has again confirmed these results, and shown that not only is the *size* of the anode a factor to be taken into account, but also its *nature*, inoxidisable metals like platinum causing a greater deficit in the amount of copper deposited than occurs with copper. Oettel has further shown that the addition of an oxidisable body to the electrolyte *decreases* the loss of copper, so that there can be little doubt that the loss of copper is occasioned by the formation of some highly oxidised body in the electrolyte, and that this body is the persulphate of copper described by Marshall. It is noteworthy in this connection that Gray mentions the deposition on the anodes in some of his experiments of a brown powder, and that electrolysed copper sulphate—as was mentioned at the Cardiff meeting of the British Association—when *at rest* deposits copper on reducing substances, such as carbon. These facts and others of a similar nature, interesting and valuable as they are to the electro-chemist, do not tend to enhance the probability of electrolytic meters receiving the *imprimatur* of the Board of Trade, and serve to explain the absence of such apparatus from houses supplied by statutory companies.

REVIEWS.

A Handbook of Electrical Testing. By H. R. Kempe. Fifth Edition. (London: E. and F. N. Spon.)

The particular feature or features which constitute a handbook are as difficult to determine as those which constitute an engineering pocket-book, if one is to be guided by the examples of either which one meets with. Is a handbook a small, portable volume easily carried in the hand, or is it a ponderous tome? The work before us started as the one, and has passed through five expanding stages till it has become the other. Is a handbook a volume which contains something handy, and which one may want on the spur of the moment in practical work? The work before us consists chiefly of that which one would never want in practical work, and much that would be of little use even to a theorist. Then, again, what is electrical testing? Since the first edition of this book made its appearance, electrical work has come to be something more than telegraphy, and electrical testing something more than "loop tests," "bridge tests," "Mance's methods," *et hoc genus omne*. Yet there is in the book no sign of this great change; it remains purely telegraphic, and, for the most part, submarine-telegraphic, and has nothing to say on the subject of the important heavy electrical tests which its title would lead one to demand from it. Obviously the book before us is a book for only one section of electrical engineering, and as such we will now consider it. In its 550 pages there is a matter of about 90 tests described, of which 43 relate specially to cable testing, and 27 of these to the localisation of faults in submarine cables. Of the remainder, a large proportion is devoted to tests on the E.M.F. of primary batteries, chiefly of low voltage, 10 of these tests being given. Besides these battery tests, there are a number of methods of measuring potentials, and the remaining portion of the work is devoted principally to simple tests of galvanometer resistance, capacity and ordinary resistances. It will be seen, then, that this volume of 550 pages does not cover any very large extent of ground. This is explained by the altogether disproportionate amount of space—if we mistake not the purpose of a book of this sort—which is devoted to "proofs" of tests, and to elaborate mathematical discussions of the

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"probable error" and "best conditions" for each test. Let it not be supposed that we despise the proof of a test, nor that we would not be as anxious as anyone else to know the probable error and the best conditions in making it. The point lies in the waste of time and space which arises from the inordinate elaboration and monotonous repetition of these things. Would it not be much better, would it not save a great deal of space, if a separate short chapter on the *principles* of determining these things were given once for all the tests, the rest being left to the wit of the reader? A student who has so far advanced in mathematical learning as to be able to follow Mr. Kempe's repeated proofs would have no difficulty—nay, would find it easier—to adapt a general discussion to each particular case he might require. Mr. Kempe's logic is tedious; it lacks that imagination which leaves something to be done by the reader; it prefers to build up a pile of special examples, rather than to evolve a neat and general proof. Referring now for a moment to details, we have been rather surprised to find no definitions of the legal standards of resistance and voltage in the book, the nearest approach being the definitions of Matthiessen's copper standard and of Clarke's cell. We should have thought, too, that in a work so largely devoted to matters concerning submarine cables, some reference would have been made to the much-discussed K R law, but we can find none.

Notwithstanding all its defects, this work probably meets the wants of a certain large section of electricians who are willing to ignore the useless matter in order to get the useful truths it contains. The book is accurate, and, as such, it is reliable. The pages after pages of tedious mathematics do not destroy one jot of the value of the short descriptions and accurate diagrams of the tests which it also contains. That the work has attained to its fifth edition and is now adopted by the Postal Telegraph Department makes it evident that it is a not unimportant factor in technical literature.

The Elements of Physics. By HENRY S. CARHART, M.A., and HORATIO N. CHUTE, M.S. (Boston: Allyn and Bacon.)

That well-known physical law—the law of the pendulum—has led the authors to produce this text-book of physical science. Not alone in the to-and-fro motion of a mass particle at the end of a string, or in the ebb and flow of the ocean tide, but in all the affairs of men, of nations, of the entire universe, can the operation of this law be seen. The stress and failure of each opposite extreme induces, in time, the adoption of the other, producing a ceaseless rhythmical oscillation between equally impracticable limits. Such is the law; and it operates on the curriculum of the physical laboratary. "A few years ago it seemed necessary to urge upon teachers the adoption of laboratory methods to illustrate the text-book," write the authors of this work; "it would now seem almost necessary to urge the use of a text-book to render intelligible the chaotic work of the laboratory." This view of the situation we completely endorse; and the remark is equally true of laboratories on this side of the Atlantic as of those in America. Time has shown the fallacy of setting each student to re-discover the laws of physics by actual experiment and observation in a laboratory. Life is not long enough for it. The true function of a physical laboratory is not to monopolise instruction, but to supplement the lectures, to instruct the student in the principles of inference from experiment, and in the handling of apparatus. The reaction against the old-fashioned "recitation" method has been more than complete, it has been severely overdone—the pendulum has travelled too far towards the opposite extreme. It is now swinging back again. One of the deplorable consequences of this last anti-phase has been the flood of text-books for students, which bids fair to carry the pendulum bob far into another impracticable region. This may be looked on as the *hysteresis* of the cycle—the purely wasted energy!

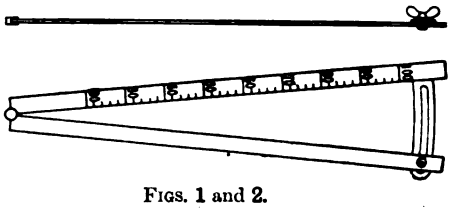
The particular contribution to this flood by the authors of the work before us is undoubtedly superior to the average. It forms a compendium of the elementary physical sciences, comprised within a volume by no means large, but which is composed of well-selected matter, written in a lucid style. The treatment is experimental and illustrative, rather than mathematical, although each chapter is supplemented by a list of problems to be worked out by the student. After the introductory chapter, the Mechanics of Solids are treated, the student being familiarised with force, energy, and matter. Chapter III., on the Mechanics of Fluids, is less satisfactory, the treatment being conventional, not to say antiquated. A short chapter on Heat follows. Magnetism and Electricity are dealt with next, in what is by far the longest chapter in the book. This part is a careful compilation; and, with the exception that we think the space devoted to the applications of electricity might have been more usefully disposed, we have no objection to it. In a small book covering so wide a field, it is rather a disproportionate arrangement to devote space to dynamos and the different kinds of magnet winding; and the book loses sight of itself where it strays into descriptions of motors, telegraphs, and telephone circuits. Chapter VI. deals with Sound, and contains some original simple experiments for illustrating the principles of that science. The last chapter, on Light, deals with the chief phenomena of visible radiation. On page 314, the mode of using the Bunsen photometer is incorrectly described. Instead of adjusting the grease spot till it becomes "invisible" or "is least conspicuous to one viewing it from a position in line with the three objects" (the two lights and the screen), it is not only customary but necessary to view it obliquely and at a definite angle. This is usually effected by means of inclined mirrors. The best adjustment is when the appearance of the grease spot is similar when viewed from both sides.

THE TAPER OF COMMUTATOR SECTIONS.

BY F. M. WEYMOUTH.

When the segments or bars for a commutator are cast, instead of being rolled, they require to be machined or filed on their sides before being put together. To secure accuracy in this operation, it is necessary that the parts be worked up to a gauge. In this manner the requisite exactness in both thickness and taper may be obtained. When, on the other hand, drawn copper is used, it is equally necessary to specify the exact taper in ordering, and generally to send a gauge, sample, or template to the manufacturer.

A very useful and simple gauge or tool was designed for this purpose and adopted in 1886 by Messrs. Goolden and Trotter. This instrument is illustrated on a reduced scale, in Figs. 1 and 2 herewith. There are two ways of stating



FIGS. 1 and 2.

the taper for a commutator segment or strip. One is to give the angle between the sloping sides, and the other is to describe the slope of one side in relation to the other side as a gradient of "one in so many." As a circle is divided into 360 degrees, the angle for a segment is, of course, arrived at by simply dividing the 360 by the number of segments, or "parts." Thus the angle of a strip for a "40 part" commutator will be 360/40 = 9degs. But it must be noted that this assumes the parts put together *without the insulation*. This point requires attention. It has to be borne in mind that the mica or other insulation between the segments, does *not* taper, but is of even thickness. Fig. 3 shows how all the strips of a commutator are made to fit in the first instance, *minus* the insulation; while Fig. 4 shows the same parts put together *with* the insulation. This latter at once increases the diameter; and it should be noted further, in this latter case, that the sides of the sections, if continued inwards, do not meet at the centre. Here, in fact, is demonstrated how great an effect on the ultimate diameter the insu-

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lation may have, especially when there are a large number of segments, and a high voltage requiring the insulation to be thick. In designing a commutator, it may be observed that

$$r = R - \frac{n \times d}{2\pi}$$

where r is the inside radius of the commutator when put together without the mica, R the inside radius of the complete commutator, n the number of sections, and d the thickness of the mica or other insulation.

The principle of the gauge under discussion is illustrated in the diagram Fig. 5. The hatched portion represents the section of a commutator segment. In trigonometrical language, the line $b\,c$ represents the "cotangent" of the angle $c\,a\,y$, otherwise denoted by the letter θ, which is the angle of the strip.

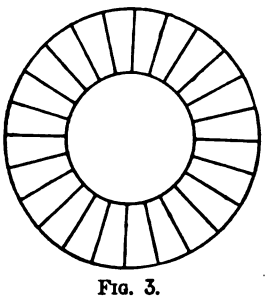

Fig. 3.

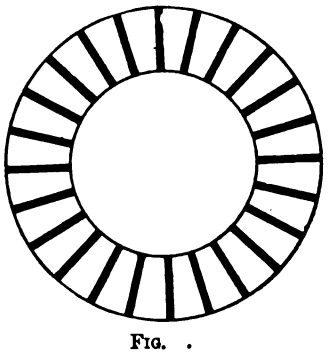

Fig. .

The radius $a\,b$ is unity. It will thus be observed that the taper of the section may be expressed in terms of the gradient of the line $a\,c$, as compared with the horizontal line $x\,y$, obviously to be determined by the number of times $a\,b$ will "go into" $b\,c$. Assuming a 40-part commutator, when θ will be 9°, and making use of a table of natural sines, we find the numerical value of the cotangent $b\,c$ for the angle $\theta = 9°$, to be 6·3138. The line $a\,b$ being unity, the gradient of $a\,c$ will thus be 1 in 6·3138, which may be given as the taper of the segment.

It so happens, that for any number of segments in a commutator, from about 40 up to 160 or 180, if the number of segments be divided by the corresponding numerical cotangent of the angle of one of them, a constant, 6·3, is arrived at when not exceeding one place in the decimals. This is, therefore, useful, since by simply dividing the number of segments by this constant, we arrive at the taper in terms of a gradient.

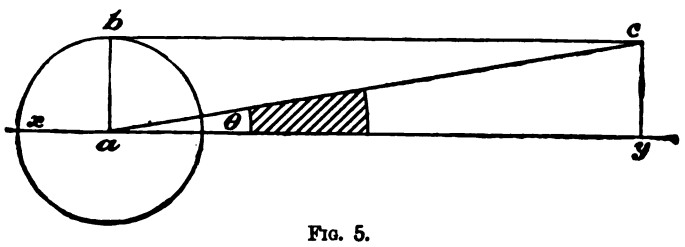

Fig. 5.

Referring again to Fig. 5, it will be observed that the triangles $a\,b\,c$ and $a\,c\,y$ are similar; and $c\,y = a\,b$, and $a\,y = b\,c$. It is also obvious that if we shorten the parallelogram $a\,b\,c\,y$ by moving $c\,y$ nearer to $a\,b$, we shall open the angle θ; and *vice versâ*. Conversely, if the angle be opened $b\,c$ will become shorter, and if θ be closed $b\,c$ will lengthen. Thus for a large number of segments, and consequently a small angle θ, $b\,c$ and $a\,y$ will be much longer than with a small number of segments and consequent large angle. Now $a\,b$ being unity, so also is $c\,y$. The distance of $c\,y$ from $a\,b$, that is, the length of the cotangent $b\,c$, may be calculated for every feasible number of segments in a commutator in the manner stated above, that is, by dividing the number of segments in each case by the constant 6·3. This being done, the various points where $c\,y$ will stand on $a\,y$, in accordance with the number of segments and consequent size of angle θ, may be marked on $a\,y$, and the corresponding number of segments figured on also. A scale will thus be formed on $a\,y$. Subsequently, in order to fix $a\,c$ at the proper slope for any number of segments, it will be merely necessary to make $c\,y$ stand perpendicularly on the mark on the scale having that number.

It is in this manner that the scale on the gauge under discussion is formed, with a standard unit (corresponding to $c\,y$, Fig. 5), of one inch. Hence, to use the tool, a flat standard inch gauge, held perpendicular to the edge of the scale, is placed between the jaws exactly at the mark denoting the number of segments. This sets the gauge open at the required angle or taper. In giving instructions, the distance of the inner edge of the segment from the centre (a, Fig. 5), may also be given; though this must be the small radius with the insulation absent, as shown and explained in connection with Fig. 3. Thus the taper and thickness of the segment are both stated. The gauge, after having been set, is fixed by the fly-nut and cross arm, as shown in the illustration.

THE MAGNETIC CURVE TRACER.

BY PROF. EWING, F.R.S.

The Magnetic Curve Tracer, which was briefly described in *The Electrician* when it was first shown at the Edinburgh meeting of the British Association last August, has now taken a shape which is intended to fit it for use in the workshop as well as in the laboratory, as an instrument for investigating the magnetic qualities of iron. It .ets magnetic quality by exhibiting the curve which connects the magnetisation B with the magnetising force H in any magnetising process. Nothing less than a determination of this curve and of the area which it encloses when the magnetising force is carried through cyclic processes of reversal will suffice to show the comparative suitability of different samples of iron for such electrical uses as the construction of transformer cores. Experiments show that marked differences of magnetic quality are found among specimens of iron wire or sheet which might fairly be rated as soft, and even the knowledge that a particular specimen has high permeability is no guarantee that the loss of energy due to hysteresis, when it is carried through a process of reversal, may not be relatively great. It may be hoped that an instrument which allows comparative tests to be made readily, and at the same time with great completeness, will be of some service to those whose business it is to select their material from batches of nominally "soft," but far from uniform, metal. Tests made by the curve tracer should also be useful in cases where the manufacturer is in quest of the opposite quality, namely, that magnetic hardness or high coercive force which renders certain steels pecu' liarly fit for the construction of permanent magnets.

The curve is exhibited, as readers of *The Electrician* may re member, by the movement of a spot of light reflected on a screen by a mirror, which receives two component motions, one (vertical) proportional to B, and the other (horizontal) proportional to H. Fig. 1 shows the instrument in the form in which it is now made by Messrs. Nalder Brothers. The diagram (Fig. 2) is reproduced to show the function of the various parts. The mirror is pivoted on a single needle-point, which leaves it free to turn both ways, and is connected by threads to the middle of two wires, A A and B B, in such a manner that when either of the wires sags the mirror suffers a corresponding deflection. The threads are kept taut by light springs, the tension of which is adjustable. The wires are stretched in narrow slots, forming gaps in two magnetic circuits, D D and C. One of these circuits, D D, is made up of the iron or steel to be examined, along with suitable pole-pieces and yoke, and the current which passes through the magnetising coils of this circuit passes also through the stretched wire, B B, in the gap of the other magnet. The other magnet is constantly magnetised by a steady current, and a steady current also flows through the stretched wire A A. Hence, when the magnetising current of D D is altered the wire B B sags out or in, and gives horizontal motions to the mirror which are proportional to the magnetising force acting on D D. And when the magnetism of D D is altered, the wire A A sags up or down, giving vertical motions to the mirror which are proportional to the changes of magnetism.

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The samples to be tested form the arms of D D. They may be solid rods, or rods built up of thin strips or of wire. The rods supplied with the instrument are of soft sheet-iron, built up of insulated strips, with a net cross-section about 1in. by ½in., and about 18in. long. In preparing other rods for comparison of magnetic quality, the same dimensions are to be chosen as those of the standard rods. Clamps are provided at the pole-pieces to allow the rods to be readily inserted and removed.

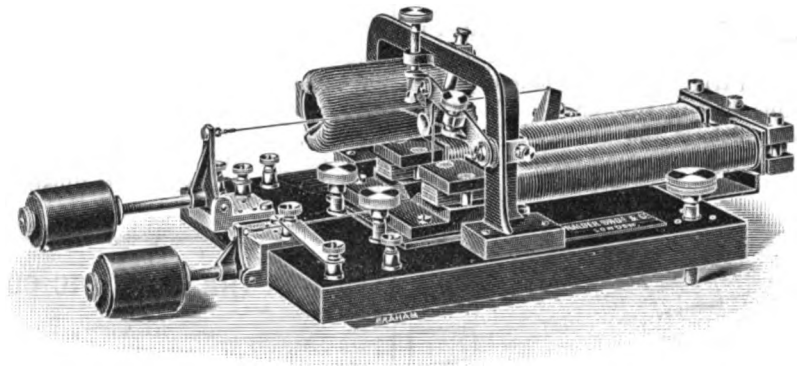

Fig. 1.

The same constant current will serve for the wire A A, and for the magnetising coil of the tubular magnet C. A current of about four amperes will serve well, but more or less may be used, according to the amount of movement which it is desired to give to the mirror. The amplitude of the movements can also be regulated by shifting in or out the weights on the bell-crank levers which keep the stretched wires tight. For high-speed work the wires should be kept very tight, and a small mirror should be used. The magnetising current must be made to vary in a continuous manner; not by sudden makes and breaks. When these precautions are taken, magnetic cycles may be performed so rapidly that the reflected light appears on the screen as a continuous curve. A special commutator is supplied to allow of rapid but gradual variations and reversal of the magnetising current. It consists, essentially, of two fixed and two revolving plates of zinc, immersed in a solution of zinc sulphate.

In ordinary testing, it is more convenient to make the magnetic changes occur slowly, and to mark with a pencil the successive positions of the spot on the screen. A sheet of paper on a small drawing-board, set up against a wall or other vertical support, is a suitable screen, The source of light may be an ordinary galvanometer lamp, furnished with a pair of cross wires instead of the usual single wire. For high-speed work, a small spot of light is necessary, which is obtained by placing a screen with a small hole in it just in front of the lamp. Horizontal and vertical datum lines are marked by moving (by hand) the wires B B and A A respectively, and marking the path of the spot. A variable resistance is to be inserted in the magnetising circuit of D D, to allow successive points of the magnetising curve to be obtained; two zinc plates suspended near together in a weak solution of zinc-sulphate, in such a way that they can be more or less deeply immersed, will serve well for this purpose. A rapid commutator is also to be put in this circuit, to allow the specimens under test to be demagnetised by rapid reversals of continuously-diminishing magnetising force, if it is wished to determine the curve of *initial* magnetisation. In comparing other samples with the standard bars, care must be taken to preserve the same scale of **B** and of **H**, by not changing the constant current in the wire A A and magnet C, nor the tension of the stretched wires.

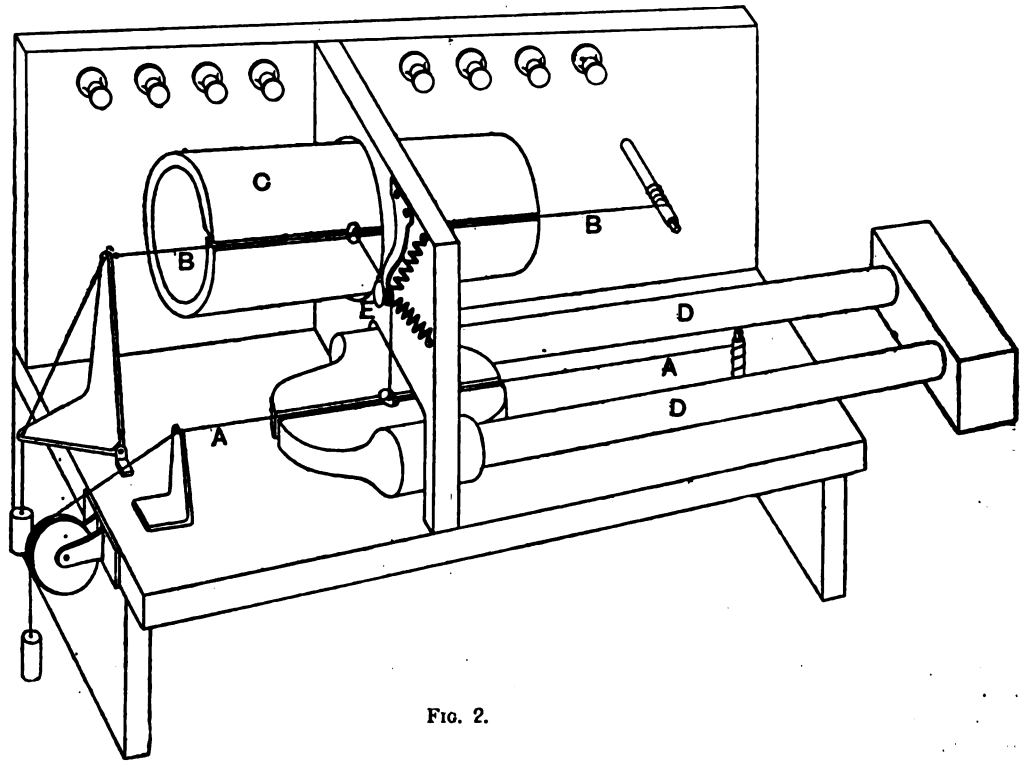

Fig. 2.

The absolute scale of **H** may be calculated, if required, from a knowledge of the number of turns in the winding of the magnet limbs, and that of **B** may be found by means of an auxiliary ballastic galvanometer, by winding an induction coil of a few turns round one or both of the limbs.

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Fig. 3 shows the electrical connections with the terminals as they are placed on the slate base of the instrument.

Terminals 1 and 2 are those of the coil which magnetise the tubular magnet C; terminals 5 and 6 are those of the main magnet coils on D D. The constant current is supplied by P, and, taking the course 1, 2, 3, 4, passes in series through the magnetising coil of C and the stretched wire A. The variable current is supplied by Q, through the commutator K and adjustable resistance R. Taking the course 5, 6, 7, 8, it passes through the main magnetising coil and the stretched wire B. The copper strip which is used to connect 2 with 3 may be put

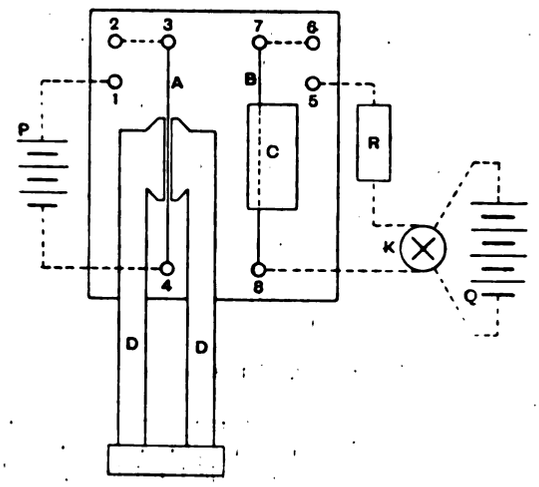

Fig. 3.

between 1 and 3 instead, 2 and 4 being then the battery terminals in that circuit. The effect of this is to change the general slope of the figure on the screen from right to left, or *vice versâ*. One of the two arrangements is right when an ordinary screen is used; the other is right when the screen is a piece of tracing paper or ground glass, viewed from behind.

Care should be taken to adjust the instrument, so that when a complete cycle of magnetic reversal is performed the figure on the screen will be symmetrical, with the extremities equi-

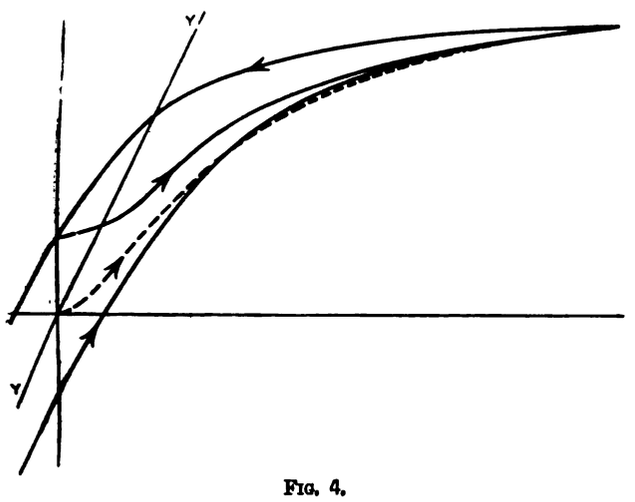

Fig. 4.

distant from the zero point or origin which corresponds to the condition of no current in B and no magnetism in D D. To secure this, see that the stretched wires are, as nearly as may be judged, in the middle of their respective slots, both vertically and horizontally. Set the mean position of the mirror perpendicular to the pivot needle, by adjusting the needle's position by the screws provided for that purpose. The light springs which keep the connecting threads taut are to be set so that they remain considerably stretched even when the mirror moves to its furthest limit in the direction tending to slacken them.

Fig. 4 is an example of the curves obtained by the instrument shown in Fig. 1. It is a copy of one half of a cyclic curve of reversal, along with the initial curve taken after demagnetising the specimen by reversals, and also the curve obtained by reapplying the magnetising current after it had been reduced from its maximum to zero. Owing to the existence of an air gap in the magnetic circuit under test, the diagram is sheared over to the right, and true values of the magnetic force would be found by measuring horizontal distances from some such line as Y Y, instead of from the vertical

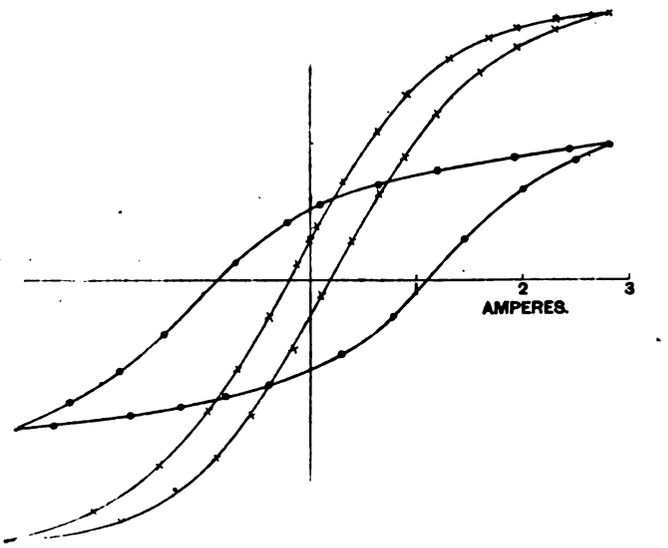

Fig. 5.—Cyclic Curves for Iron and Steel, taken by the Magnetic Curve Tracer.

line. This shearing does not affect the *area* enclosed by the cyclic curves of reversal, and need not, therefore, be taken account of in measuring the comparative amounts of energy dissipated by magnetic reversals in different specimens, or in the same specimens with different values of the magnetism.

Figs. 5 and 6 give further examples of the work the curve-tracer does: they are also tests taken with the instrument of Fig. 1. In Fig. 5 the higher and narrower curve gives the effect of carrying the standard soft-iron bars through a magnetic cycle by reversing a current of three amperes in the magnetising coil. The flatter and wider cycle on the same diagram was obtained (with the same strength of magnetising current) after a pair of steel bars had been substituted for the standard soft-iron bars.

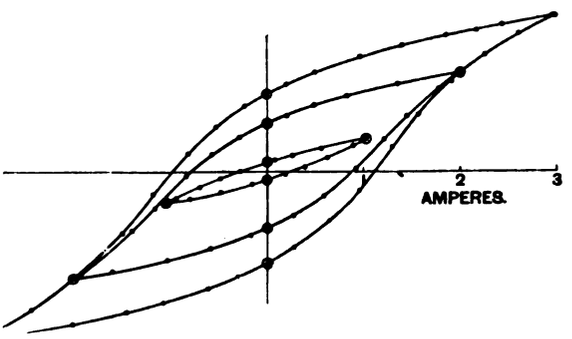

Fig. 6.—Cyclic Curves for Steel, with various Grades of Magnetising Force, taken by the Magnetic Curve Tracer.

Fig. 6, again, shows three cycles obtained with a pair of steel bars, the limits of the magnetising current being three amperes, two amperes, and one ampere respectively. Curves of this type show how readily the instrument may be employed to determine (from the enclosed areas) the relative amounts of heating due to magnetic reversal under different grades of magnetising force, or with different values of the limiting magnetisation.

In these instances the cycle was gone through quite slowly, a pause being made at each of the marked points. When the cycle is gone through comparatively fast, the presence of time lag becomes very manifest, especially when the bars are solid and when the material is soft iron. It is obvious from the behaviour of the spot of light in such experiments that the

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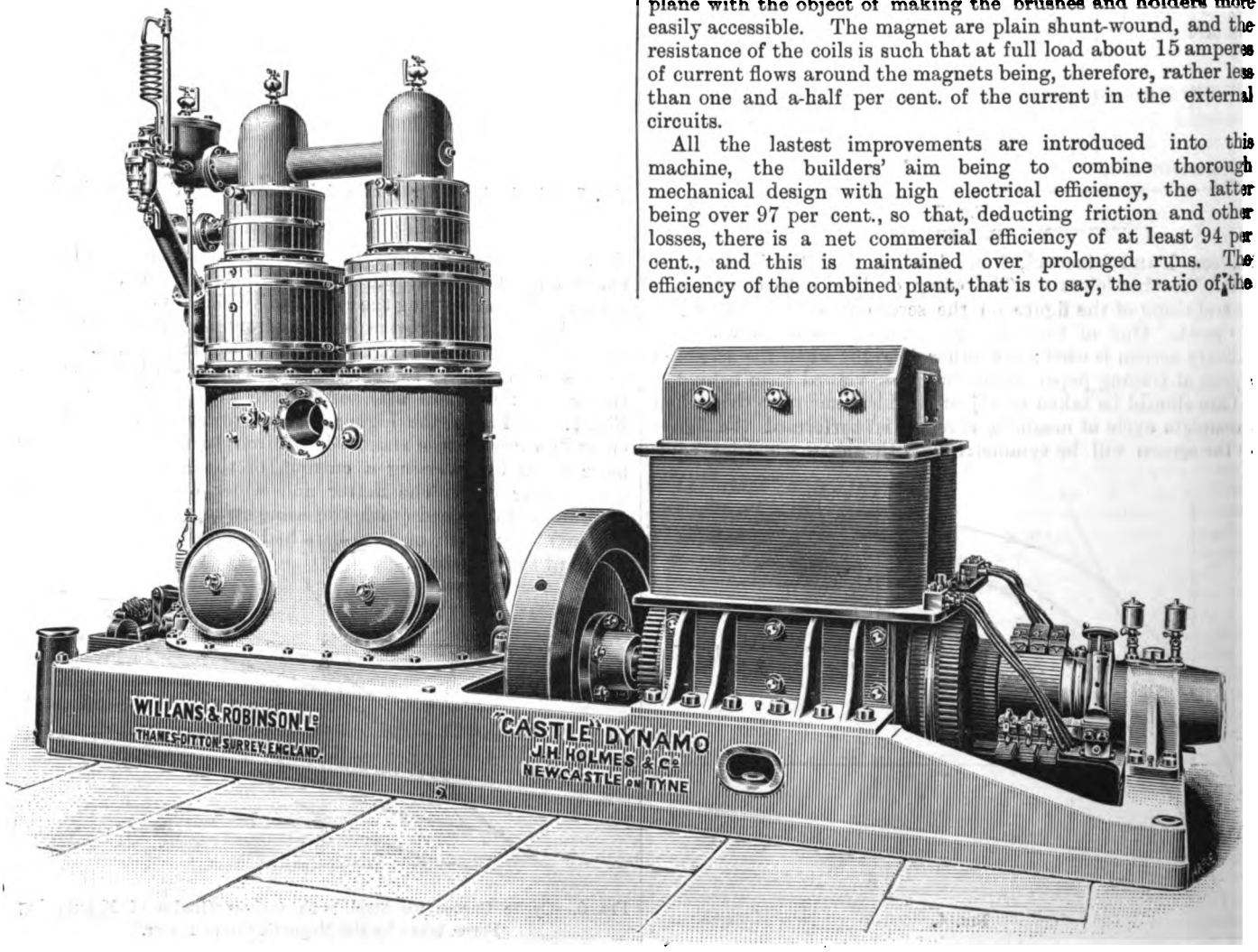
time lag is due to no peculiarity of the instrument, but is a genuine feature of the magnetising process.

In addition to its use for determining areas such as those of Figs. 5 and 6, for comparing the magnetic qualities of different samples of iron, and for investigating the properties of magnetic curves generally, the instrument may be used as a galvanometer by making the current to be measured pass through either of the stretched wires, while the magnet, in the slot of which the wire is stretched, is kept in a constant state of magnetisation. This will be found useful in cases where an extremely dead-beat indication is wanted, and by making the spot of light register its position photographically on a moving plate or paper satisfactory records of rapidly fluctuating currents may be obtained.

A LARGE "CASTLE" DYNAMO.

The "Castle" dynamo here described is of Messrs. J. H. Holmes and Co.'s latest improved drum armature type, wound with bar conductors, and is designed for aluminium smelting.



It has an output of 125 volts and 1,025 amperes at a speed of 350 revolutions per minute; thus being capable of supplying current to more than 4,000 lamps of 8 c.p. each. The armature alone weighs considerably over two tons, and has a core built up of about 1,700 thin Swedish charcoal iron discs, carefully insulated from each other by specially-made parchment paper of unusual thinness. The discs are mounted directly upon a steel shaft, and are driven by a key running the entire length of the core, and they are notched in such a manner as to leave three ventilating spaces next to the spindle. The bar conductors are built up of copper strips, so split up and twisted as to prevent, as much as possible, the formation of "eddy" currents, and they are driven in a positive manner from the core by means of drivers which rest in channels at intervals round the periphery; the end crossings or connections are made of copper strips of ample cross-section and without joints, arranged in a compact form at each end of the armature, without, however, interfering with the efficient ventilation of the core to the channels described above. Great care has been exercised in the design of this machine, both by keeping the current density in the conductors small and by eliminating eddy currents, to ensure the temperature of the machine after lengthened runs being as low as possible. The over-all dimensions are 13ft. × 5ft.

The field-magnets are of best annealed iron forgings, machined all over, and weigh, with their copper-windings, about eight tons. These forgings rest upon a brass bed lying on a concrete foundation, and are steadied at the sides by non-magnetic brackets, fastened to the Willans' Patent Combination Frame forming the base of the engine and carrying the outer bearing of the armature. The brush-holders are of massive proportion suited to the large currents they have to convey, and the connections between the armature and the commutator are so arranged as to bring the line of commutation in to the horizontal plane with the object of making the brushes and holders more easily accessible. The magnet are plain shunt-wound, and the resistance of the coils is such that at full load about 15 amperes of current flows around the magnets being, therefore, rather less than one and a-half per cent. of the current in the external circuits.

All the lastest improvements are introduced into this machine, the builders' aim being to combine thorough mechanical design with high electrical efficiency, the latter being over 97 per cent., so that, deducting friction and other losses, there is a net commercial efficiency of at least 94 per cent., and this is maintained over prolonged runs. The efficiency of the combined plant, that is to say, the ratio of the electrical horse-power in the external circuit to the indicated horse-power in the cylinders of the engine at full load, was actually found to be over 86 per cent. during tests recently made at the works of the engine makers. After the engine has been run for a few months, there is little doubt but that the efficiency will reach as high as 87 per cent. or over.

The following are the results of tests of this dynamo, made at Thames Ditton on May 12, 1893, by Mr. F. V. Andersen. Another test was made on the 19th inst., when a number of visitors were invited to visit the Thames Ditton works:—

Dynamo—No. 673 "Castle" dynamo, size 22 G.R., made by Messrs. J. H. Holmes and Co., Portland-road, Newcastle-on-Tyne.

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Engine—No. 1,430 Willans patent central valve engine, size I.I. compound, made by Messrs. Willans and Robinson (Limited), Thames Ditton.

Duration of Test—Six hours.

Results of Indicating—Mean pressure :—

High-pressure cylinder actual = 32·76,	reduced for	I.P. area =	15·96
Receiver " = 8·68,	"	" =	3·89
Low-pressure cylinder			25·52
Total			45·37

Mean speed 335·7 revolutions per minute.
Low-pressure piston area = 290·4 square inches.
Stroke, 9 inches. Two lines of cylinders.

$$\text{Indicated horse-power} = \frac{335{\cdot}7 \times 290{\cdot}4 \times 1{\cdot}5 \times 45{\cdot}37}{33{,}000} = 201{\cdot}07.$$

Volts at terminals of dynamos, 128·3.
Amperes in the external circuit, 1,006.

$$\text{Electrical horse-power} = \frac{128{\cdot}3 \times 1{,}006}{746} = 173{\cdot}0.$$

$$\text{Combined efficiency} = \frac{\text{E.H.P.}}{\text{I.H.P.}} = \frac{173}{201{\cdot}07} = 86{\cdot}04 \text{ per cent.}$$

Results of Weighing Steam—
1,400lbs. of steam were condensed in 22min. 25sec., which is equivalent to 3,747lbs. per hour.

$$\text{Steam used per electrical horse-power per hour} = \frac{3{,}747}{173} = 21{\cdot}66\text{lb.}$$

Results of Temperature Tests—

Temperature of armature at start	= 29·5°C.
Do. after 6 hours' run at full load	= 57 C.
	Rise = 27·5.
Temperature of room at start	= 23·3°C.
Do. do. finish	= 26·0°C.
Difference	= 2·7

Therefore, the actual rise in armature due to running of the machine was 27·6—2·7 = 24·8°C. = 44·7°F.

THE CONTINUOUS CONTROL OF ELECTRIC LIGHT CABLE SYSTEMS.*

BY DR. M. KALLMANN.

The enormous sums spent in the cables of electric lighting stations during the past few years has made the problems of how best to preserve them from injury, and, when injured, to find the fault expeditiously, two of the most important questions of the day ; and the best means of grappling with such a problem is to be quite clear on the subject of all possible causes of disturbance or injury. To examine all possible means of preserving cables is not the object of this Paper, which is directed to the questions (i.) of continuous insulation tests ; (ii.) of automatic location of faults.

Dr. Frölich, in a valuable Paper† read in December, gave a whole series of methods for the first of these purposes ; but the author considers that they entail the expenditure of much time and material, and in admitting that his methods are useless if the middle wire be earthed at any point, Dr. Frölich has shown the inapplicability of his plan to nearly all central station networks, as in nearly all cases the insulation of one pole is more or less negligible. To make the control effective, it is necessary to have an arrangement which stands or shows an alarm signal whenever the insulation falls below a certain given amount, and the best method of doing this is by means of signalling voltmeters, placed between the pole and earth. The Weston voltmeter is very useful for the purpose, but while this arrangement is satisfactory for small work, it loses its value, to a great extent, on very large cable systems. The author has devised a system of signalling at the station the insulation condition of the smallest possible portion of a large network, but before going into the theory of it he gives an account of some practical arrangements of a Berlin central station, which have been working during many months.

In such a large cable system as that of Berlin injuries are constantly happening to the cable, through workmen and others, and the device is intended to give an alarm at the station whenever such an accident occurs, and to show the district within which it has taken place. In order to do this, the insulated pilot wires, which are also used for voltmeter wires to show the pressure at different points in the system, are made use of. The arrangement is shown (on a two-wire system for simplicity's sake) in Figs. 1, 2, 3. The author then enters into details of the Berlin system, which has about 400 miles of street conductors divided into 115 districts, the area supplied being about 2·5 square miles, and containing about 650 junction boxes, whereby taking out fuses every conductor can be cut off. In Berlin each pair of pilot wires serves an area of about 70,000 square yards, and a cable length of about 1½ mile ; and it is, therefore, generally not necessary to open more than three boxes in order to find the defective cable and cut it out. The arrangement of the combination apparatus is shown in Fig. 1, the essential point being that the pilot wire in each cable is connected to the opposite main, so as to keep up a difference of potential between it and the cable in whose sheathing it is run, in Berlin amounting to 220 volts. At the station each feeder pilot wire has

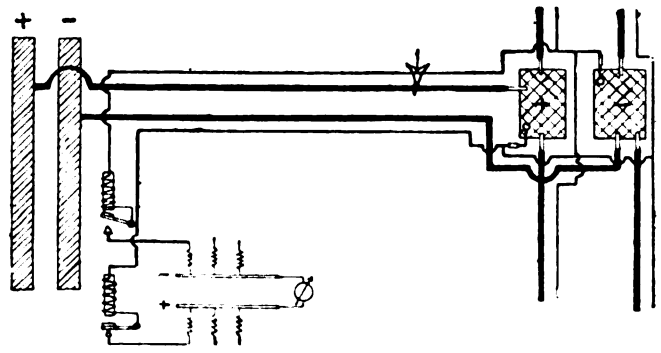

Fig. 1.

a relay in its circuit of suitable sensibility, for the purpose of attracting an armature and ringing a bell if any disturbance of the potential difference between pilot wire and main takes place. By this means any breakdown in insulation is automatically signalled at the station, without disturbing the measurements of pressure which are carried on through the same wire ; and the relay which has been set in action drops a number, which indicates the district in which the breakdown has taken place, where the defective section can easily be detected and cut out. The author states that practice shows that, even if the cable is only severely injured, without actually short-circuiting the pilot wire to the cable, the earth-current quickly destroys the insulation and brings the two into contact within a short space of time.

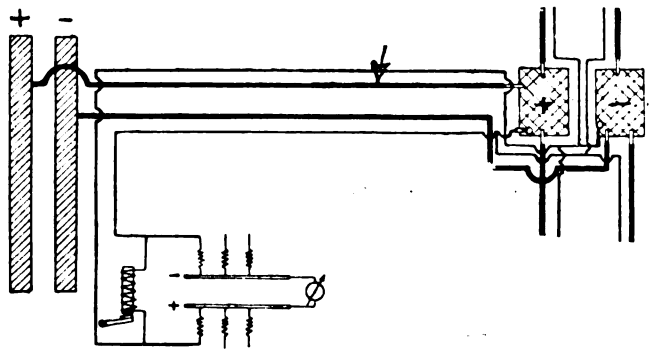

Fig. 2.

The arrangement of Fig. 2 enables one relay to be used for both pilot wires belonging to the same district. It is found that the sensibility can be so arranged that any defect of insulation, even short of a short circuit, is immediately signalled. Fig. 3 shows an arrangement by which the difference of potential between the pilot wire and main can be lessened if necessary, but no difficulties have arisen in Berlin from this source.

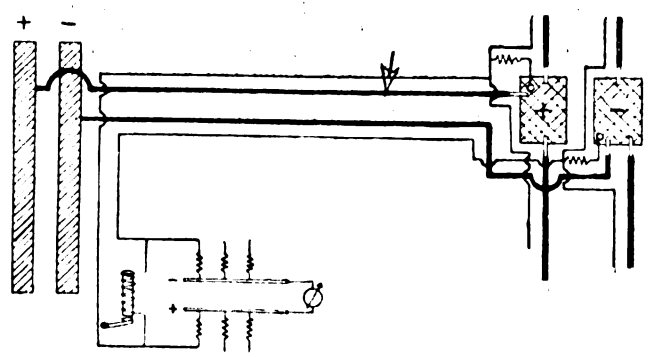

Fig. 3.

In addition to this signalling apparatus, there is provided for the Berliner Elektricitäts-Werke a system of automatic earth-contact signalling arrangements, which can be applied to any system of cables of whatever kind, and of whatever size it may be. The

* Abstract of a Paper read before the Electrotechnischer Verein.
† See *The Electrician*, Vol. XXX., February 10, 17, 24, 1893.

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theory of this arrangement rests on the fact that, when an "earth" takes place, most of the energy is converted into heat in the immediate neighbourhood of the "earth," and there is only a small fall of potential through the earth itself. The idea is to determine the potential at various points in the earth when the contact takes place; the position of the fault is then shown by a relay and a 10-volt voltmeter at the station.

Fig. 4, which is self-explanatory, shows the arrangements for two districts. From the points in the network most removed from one another—for example, from every feeder junction box—an insulated wire P leads to the station, and passing through a relay R, is put to earth. From the other pole, or middle wire, a conductor which can be cut out leads to earth at the station, if necessary through a resistance. Each pilot wire P is also put to earth in its own district, and the relay has, therefore, on its terminals the difference of potential between the earth at the station and at the district corresponding to it. This difference is small, even if several hundred amperes are passing to earth, as the fall of potential is so very local; and the disturbance can be measured on a low-tension voltmeter quite easily. This controlling device can be made of any desired degree of sensibility by suitably winding the relays; and, as in Berlin it is not desirable to have it too sensitive for fear of needless alarms and so on, the relays are wound accordingly (1·8 volts for the Schiffbauerdamm district, for example). If the short circuit is very severe, many of the nearer relays may also give a signal, as the required difference of potential may be reached nearer the station. To find the position of the fault in this case, a voltmeter, G, is used, consisting of a simple telegraphic galvanoscope. This can be put between the "earth"

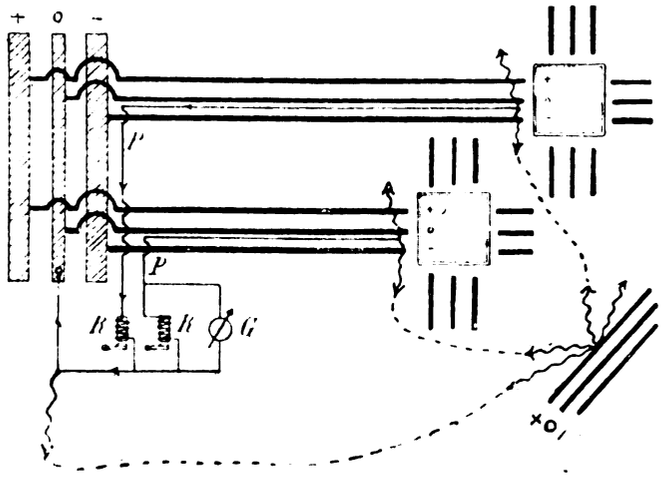

Fig. 4.

at the station and those of the various districts, by means of a switch passing over a series of blocks connected to the control wires. The galvanoscope works either with 0·5 or 5 volts at its terminals for maximum reading. The contact at which the highest potential difference occurs is that of the district in which the "earth" is to be found.

The remainder of the author's Paper is taken up with the theoretical aspect of this arrangement and a description of his experiments. He concludes by calling attention to the two interdependent systems by which a complete and continual control over the whole cable network is attained, the first directed chiefly to direct injury of the street cables, while the second in general watches over all faults of insulation, signalling when they pass a certain limit, and applicable not only to underground covered cables, but also to bare conductors in culverts and to overhead wires; while it controls, in addition, all the house installations, thus making the control most complete and effective.

ON THE REACTION OF THE ARMATURE CURRENT ON THE FIELD.*

BY J. FISCHER-HINNEN.

The method of Hopkinson for the predetermination of the magnetising force required in dynamos is found to be only correct in certain cases when, through weakness of the armature field, its reaction on the magnets may be neglected. Many attempts have been made to get some quantitive predetermination of these reactions, but no universally applicable methods have yet been published; most of these attempts have been fully described in the technical papers. The following methods are more or less novel, and although they have no pretence to mathematical accuracy, they will be found to lead to results which will prove of practical utility.

A.—Two-pole Machines.

Fig. 1 represents one of the usual types of machine in section. It will be noted that the current is flowing in one direction in all wires above the neutral line $n\,s$, and similarly in the reverse direction in those below this line. The armature naturally becomes a magnet, the magnetic axis of which lies along $n\,s$. But since the large iron masses of the pole-pieces lie close to this armature, the magnetic lines leak out into this iron in seeking to shorten themselves as much as possible; one can assume without sensible error that they are approximately evenly distributed over the entire surface of the armature.

Calculation of the Armature Lines of Force.

If Z_a represent the total lines in the armature produced by the armature current, it is clear that Z_a may be calculated from the formula

$$Z_a = \frac{0{\cdot}4\,\pi\,A\,T}{R_1+R_2+R_3}. \quad \ldots\ldots\ldots \quad (1)$$

Where A T (for drum armatures) is the number of ampere turns on the armature, and is equal to the total number of wires (n) multiplied by the current in them and divided by the number of poles ($2\,p$). For Gramme armatures this figure must be multipled by

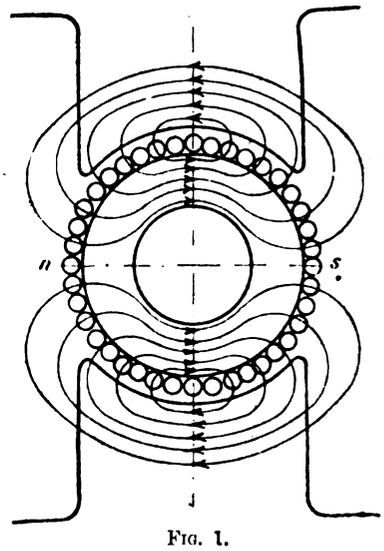

Fig. 1.

about 1·5. R_1 is the magnetic resistance in the iron of the pole-piece, R_2 is the magnetic resistance in the iron of the armature, R_3 is the magnetic resistance in the air-gap.

Two cases must now be considered, namely:—(i.) Suppose the armature lines to have a direction at right angles to those of the field-magnet, then it is clear that R_1 may be neglected. This case is the usual one, if the machines have not pole-pieces with long "horns." (ii.) If the horns of the pole-pieces are long and pointed, then in these pieces the field lines and those from the armature are in one in the same, and in the other in the opposite direction. The field is thus weakened in one and strengthened in the other. But even in this case the resistance R_1 is small compared with R_2 (the air resistance). The same is true in even greater degree of R_2; so that in reckoning Z_a we have chiefly to deal with R_3, which can be determined as follows:—

First estimate the average length of path of the armature lines, which will be distributed approximately as in Fig. 2, from which we have as the total length of air path,

$$L'_3 = \frac{2}{d\,e}\left(a\,b \times \delta + \frac{b\,e \times b\,e \times \pi}{2}\right)$$

δ = length of air gap.

If the polar surfaces are differently placed with regard to the armature, allowances must be made; but the sketch fits most modern machines.* For the area of the air path, Q'_3, take the total armature area divided by the number of poles. In toothed armatures, to allow for crowding at the teeth, a somewhat smaller area must be taken, but this is not now a common type of armature.

* Abstract from the *Elektrotechnische Zeitschrift*, February 3, 1893.

* Do not confuse L'_3 the length of the lines due to the armature in air, with $L_3 = 2\delta$, the corresponding magnitude due to the magnet. It will be noted that the value of L'_3 depends much more on the arc embraced by the poles than on the air gap.

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For example, let us suppose Fig. 3 to represent a certain achine, and let $b=16$cm., $a=8$cm, $\delta=1$cm, $c=7{\cdot}5$cm., the length armature being 30cm. From this we get :—

$$L'_3=2/24\ (16\times1+8\times7{\cdot}5)=6{\cdot}3\text{cm.}$$
$$Q'_3=2\ (16+8)\ 30 \qquad =1440\text{ sq. cm.}$$

Calculation of the Displacement of the Brushes.

Z_a = number of lines due to armature.
Z = ,, ,, due to field (per pole).

Set off graphically these values in their proper directions, and nstruct, as shown in Fig. 4, a parallelogram of forces. The sultant gives the approximate direction of the new magnetic is, so that

$$\tan a=Z_a/Z \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

here a is the angle of displacement of the brushes.

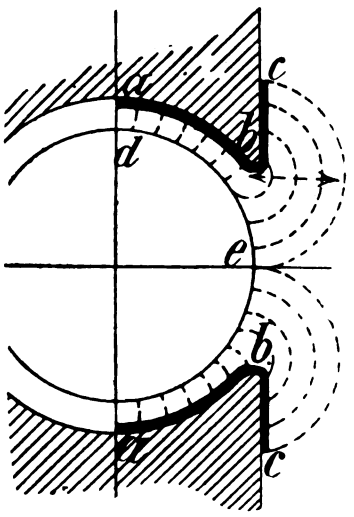

Fig. 2.

This formula is certainly theoretically open to objection, since it ppears at first sight more probable that the resultant axis would rm a right angle with Z_a, so that the sine would have to be sub-ituted for the tangent ; this is, however, obviously an erroneous ew, for it would not allow Z_a to become greater than Z, and perimental results show this to be possible. The author finds that e tangent law holds good generally, but tends to make the angle a ade small.

Let us take, as an example, the data of a two-pole machine with cinotti armature :—Diameter of armature = 62·2 cm., length of mature = 40·0, strength of current (J) = 500·0, number of wires) = 140, number of commutator sections = 70, width of teeth 0·55 cm., width of interval = 1·4 cm., $b=35$ cm., $a=14$ cm.,

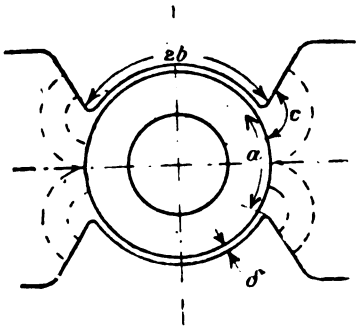

Fig. 3.

19 cm., $\delta=0{\cdot}6$ cm., Z (total field lines) = 10,800,000, armature pere turns = 17,500.

$$L'_3=11{\cdot}7\text{ cm.}, \qquad Q'_3=2{,}730\text{ sq. cm.}$$
$$Z_a=\frac{\cdot4\ \pi\times17{,}500}{\frac{11{\cdot}7}{2730}}=5{\cdot}15\times10^6,$$
$$\tan a=\frac{5{\cdot}15\times10^6}{10{\cdot}8\times10^6}=0{\cdot}477$$
$$a=25{\cdot}5°.$$

With this machine it was found that sparking was excessive ; position of least sparking was determined and found to be out 27°. It was then bored out, so that the air gap was reased to 1cm., and the pole horns reduced ; then the new dimensions of the poles were :—$b=30$cm., $a=19$cm., $c=22{\cdot}4$cm., $L'_3=18{\cdot}6$cm., $Q'_3=2{,}730$ sq. cm., $Z_a=3{\cdot}23\times10^6$, $\tan_a=0{\cdot}3$, $a=17°$. Experiment showed that the angle at which the brushes ran sparklessly was a shade over 18°.

Calculation of Compensating Winding.

The armature reaction may be considered as of two kinds, a direct and an indirect effect. In Fig. 5 the direction in which

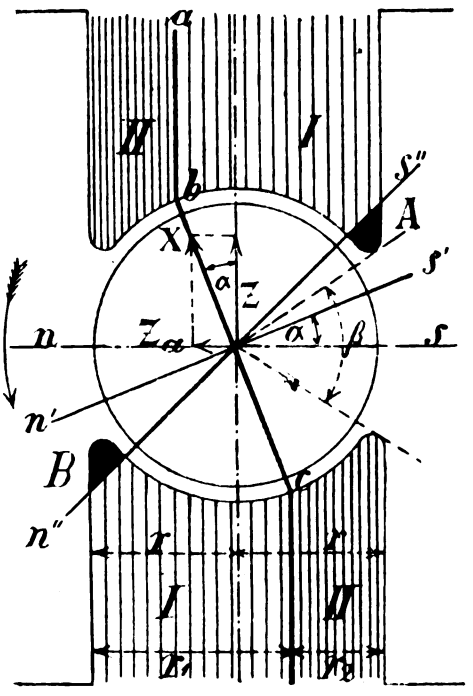

Fig. 4.

the armature lines leave the armature for the poles is shown by arrows. It is here clearly seen that those from $a\ b$ and $c\ d$ tend to reduce the field from the magnets, and to strengthen it along $a\ c$ and $b\ d$. The dominant effect is the weakening one, and amounts to

$$\tfrac{1}{2}Z_a\left(\frac{90+a}{90}-\frac{90-a}{90}\right)=Z_a\frac{a}{90}\text{ lines.}$$

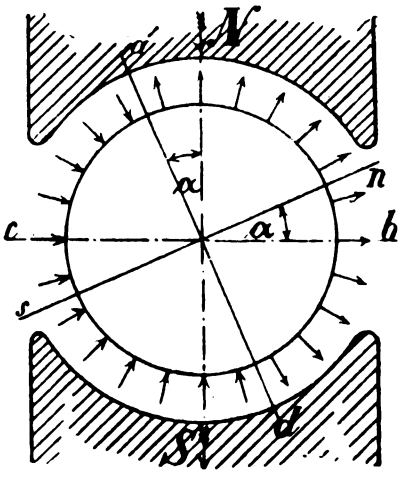

Fig. 5.

This field may be compensated for by providing the magnets with an extra winding, equal in effect to the above disturbance, that is to say, with

$$\frac{10}{4\pi}I'_3\left(\frac{Z_a}{Q'_3}\cdot\frac{a}{90}\right) \quad . \quad . \quad . \quad . \quad (3)$$

ampere turns per magnetic circuit.

The secondary effect is indicated in Fig. 4, and is the crowding of the magnetic lines in the magnets towards one side. Supposing z_1 to be the density before disturbance then approximately

$$\text{in I}: z'_1=z_1\cdot\frac{1}{1+\sin a} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$
$$\text{in II}: z''_1=z_1\cdot\frac{1}{1-\sin a} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

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It is easy to show that the result of all this is to increase the magnetic resistance in the pole-pieces, and to diminish the total number of lines of force. A weakening, however, also results from the fall of volts as the load is increased. This fall can, however, be calculated to some extent, by determining by a few preliminary calculations by well-known methods the difference in the number of lines produced. It is more practically useful to know by how many ampere turns the magnet-winding must be increased to compensate for this secondary action of the armature. The following formulæ of Hopkinson may be applied. Let L_1 represent the length of path of magnetic lines in both pole-pieces, then the number of ampere turns required for this part of the path and for the original density Z_1

$$\frac{10}{4\pi} L_1 f(Z_1) \text{ ampere turns,}$$

where $f(Z_1)$ is taken from the magnetisation curve of the iron in the usual manner.

For the new densities Z'_1 and Z''_1 we have

$$\frac{10}{4\pi}\left[\frac{L_1}{2} f(Z'_1) + \frac{L_1}{2} f(Z''_1)\right] \text{ ampere turns, . . (6)}$$

which gives a difference of

$$\frac{10}{4\pi} L_1 \{\tfrac{1}{2} f(Z_1') + \tfrac{1}{2} f(Z_1'') - f(Z_1)\} \text{ ampere turns . (7).}$$

We have then, following out the former reasoning, as total ampere turns required to compensate for the total armature reaction

$$\frac{10}{4\pi}\left[L_1 \{\tfrac{1}{2} f(Z_1') + \tfrac{1}{2} f(Z'_1) - f(Z_1)\} + L'_3 \frac{Z_a}{Q'_3} \cdot \frac{a}{90}\right]$$

ampere turns . . (8).

Let us take as an example the data of an ironclad machine with smooth-cored armature. D = 15 cm., l = 11 cm., J = 50 A, n = 150, Z = 1,000,000, L_1 = 28, Z_1 = 8,000 (cast iron poles), L'_3 = 2·2, Q'_3 = 260, ampere turns on armature = 1,900. $Z_a = 0{\cdot}28 \times 10^6$, tan α = 0·28, α = 15°40′, sin α = 0·27.

Put these values in equations (4) and (5) and we find Z'_1 = 6,300, Z'_1 = 10,900, $f(Z_1'')$ = about 250, Z_1 = 8,000, $f(Z_1)$ = 68, and finally from (8) we obtain ampere turns = 1,920 as the value of the compensating winding for the magnets, making a total of 6,500 + 1,920 = about 8,500 A T.

The author calls attention to the following interesting conclusions from the above formulæ.

(*a*) If the poles and magnets are working at a fairly low density, and the pole corners fairly close together, while Z_a is small compared with Z and δ, the air gap, relatively large, then approximately

$$Z = 0{\cdot}4\pi \text{ A T (magnets)} \times Q_3/L_3$$

where Q_3 is the area of section of pole $L_3 = 2\delta$, and also

$$Q_3 L_3 = Q'_3/L'_3,$$

and equation (2) becomes

$$\tan \alpha = \frac{\text{A T of armature}}{\text{A T of magnets}}$$

in this case also, the first term of (8) can be neglected and the ampere turns required for compensation (3) become

$$\text{A T} = \text{armature A T} \cdot \alpha/90.$$

(*b*) The compensation winding is only an increase in the magnetising force of the magnets, and its position is of no importance. The arrangement of Thomson-Houston, constructively difficult, whereby the turns are placed directly over the armature, has no advantages.

(*c*) An excessive increase of Z_1'' makes the compensating winding an impossibility, and Z_1 $1/1 - \sin \alpha$ should always be less than about 12,000 for cast or 20,000 for wrought iron. These formulæ may be utilised in designing the machine to control the ampere turns on the armature. Thus, supposing one replaces the sine by the tangent function, taking the value

$$\frac{Z_a}{Z} = \frac{0{\cdot}4\pi \text{ A T (armature)} Q'_3}{L'_3 Z}$$

then

$$\text{A T (arm)} < \frac{10}{4\pi} \frac{L'_3}{Q'_3} Z u \sqrt{\frac{1}{1-u^2}} \quad . \quad . \quad . \quad (9)$$

$$\cdot \quad \cdot \quad u = \frac{z_1 \text{ max.} - z_1}{z_1 \text{ max.}}$$

A further simplifi ation may be obtained by assuming in this special case

$$Z_a/Z = \sin \alpha, \text{ instead of } \tan \alpha,$$

when (9) becomes

$$\text{A T (arm)} < \frac{10}{4\pi} \cdot \frac{L'_3}{Q'_3} \cdot Z \cdot u \quad . \quad . \quad . \quad . \quad (10)$$

This simplification tends to make the value too small, and is, therefore, on the safe side.

For example, in the machine dealt with in the last example the actual ampere turns on the armature were 1,900. The sine formula gives A T (arm) < 2,060, the tangent A T (arm) < 2,130, showing that the machine is just at the point where complete compensation can take place. It must be noted that no great accuracy should be attempted in these calculations, as, naturally, the very complicated armature reactions cannot be accurately dealt with by such simple formulæ.

B.—*Multipolar Machines.*

This section of the Paper deals with multipolar machines in a similar way (*see* Fig. 6), and arrives at the formula

Compensating amp. turns

$$= \frac{10}{4\pi}\left[L_1 \{\tfrac{1}{2} f(z'_1) + \tfrac{1}{2} f(z_1) - f(z_1)\} + L'_3 \frac{Z_a}{Q'_3} \cdot \frac{ap}{90}\right]$$

where p is the number of pairs of poles ; and examples are given.

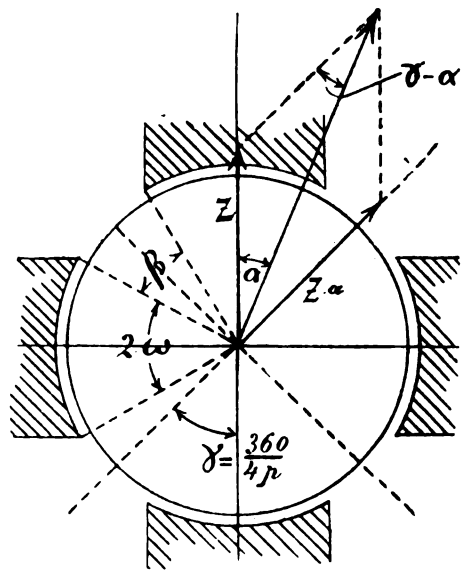

Fig. 6.

C.—Means of diminishing the Armature Reaction.

The knowledge of the amount of armature reaction affords means of designing machines with more satisfactory results ; but it is even more important for the designer to know under any given circumstances how to counteract the effect. Some methods have already been suggested, namely, diminution of armature ampere turns, large air gap and small pole faces. But these methods have the disadvantage that they are directly productive of heavy machine for given output. On the other hand a strong armature reaction means a correspondingly strong magnet winding, and this has

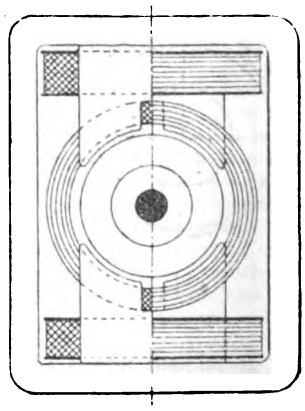

Fig. 7.

can under unfavourable circumstances become larger than the magnet winding proper. It is, however, plainly illogical to try and combat the harmful effect of the armature while the cause of the effect remains untouched. The foregoing considerations, however, point to a method of cure which has none of the above-named disadvantages.

The reactive effects depend on the ratio Z_a/Z. Now, Z_a depends on the magnetic resistance of the path in the air armature and pole-pieces. The latter factor may be considerably increased by lamination of the pole-piece in the plane of the armature axis. This

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method has also been suggested by Prof. Silvanus Thompson. It presents, however, some constructive difficulty. Tests of this cure were carried out on a Manchester type machine of 1,000 amperes and 10 volts. In its original state this machine gave a brush displacement of 60deg. at full load, and even then there was considerable sparking ; the volts fell from 16 at open circuit to 10 at full load. The same machine then had then the pole-pieces slit in the way indicated above. The result was astonishing. The sparking (up to 800 amperes) became very small indeed. A further displacement of the brushes was not possible as the angle α became greater than β. The displacement was not half as much as before, but the drop was about the same.

In conclusion, the author refers to a second method of diminishing armature reactions, which consists in placing as closely as possible over the armature a winding such that its plane is at right angles to the neutral zone. (*See* Fig. 7.) The magnetising current is in such a direction as to oppose the ampere turns of the armature ; and he points out that this arrangement is better than that of the Thomson-Houston Company, in that it works directly on the armature reaction, and consequently is not so inordinately large. If this winding has as many ampere turns as the armature itself, and distributed equally over the pole surface, then the armature reaction is entirely eliminated. This system may be used even when equation (5) no longer holds. Experiments performed with the Manchester type machine described above showed this

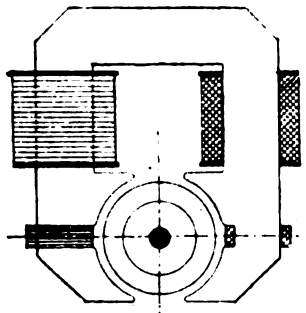

Fig. 8.

clearly ; it was run at a contant speed at 8 volts and 800 amperes, and the brushes had to be very much displaced. The compensating winding had no current in it. As the current in this winding was increased, the sparking became worse, and the brushes had to be put back. When finally the ampere turns on the compensating coil were slightly greater than those on the armature, the brushes were exactly on the neutral zone, and the measuring instruments showed 10 volts and 1,000 amperes—that is to say, nearly 50 per cent. greater output without a sign of a spark being visible.

The author therefore concludes :—"The armature reactions can not only be entirely eliminated in this way, but the output of the machine can also be considerably increased." He also points out that the coil may be arranged in two-pole machines, as in Fig. 8, but he thinks that this arrangement is not quite so effective as the former.

THE PHYSIKALISCH-TECHNISCHE REICHSANSTALT IN 1891-92.

According to a report recently presented to the Reichstag (see *Zeitschrift für Instrumentenkunde*) the work of the Imperial Physico-Technical Institute at Berlin has, during the last two years, gained considerably in extent and importance. Founded in 1887 as a branch of the Normal-Aichungs-Commission, its object has been to construct a series of electrical, optical, acoustical, and other standards, based upon the most precise measurements and the best theoretical principles, for the use of the professions and trades requiring exact physical data. In the last two years over 19,000 thermometers were tested at Berlin, and the testing of as many more supervised at the branch establishment of Ilmenau, in the midst of the Thuringian glass-working districts. Extensive investigations were conducted into the qualities of some new kinds of Jena glass, suitable for thermometers. Instruments were constructed of one of these, capable of directly measuring temperatures up to 550 C., the evaporation of the mercury being prevented by some compressed carbon dioxide contained in a bulb at the top of the stem.

Among other instruments tested, were mercury and aneroid barometers, viscosity meters, petroleum testers and manometers. Water-level indicators for steam-boilers were made of a new kind of glass invented at Jena, the so-called *Verbundglas*, consisting of two layers of different thermal expansions, which greatly reduced the strains due to differences of temperature.

The work in the electrical department consisted chiefly in the construction of standards of resistance and electromotive force, and in the testing of insulating materials. The Clark standard cell was brought to a high degree of perfection, and the effects of varying the proportions and the purity of its constituents were fully determined. A great amount of activity was concentrated upon the task of constructing the Siemens unit of resistance in the best possible manner, and the results were published in papers by Messrs. Holborn, Wien, Kreichgauer, and Jäger. Wire resistances were also constructed, chiefly of manganese-copper, or nickel-manganese-copper alloys, and a series of measurements was made to determine the conductivities of platinum and its alloys.

In the optical department the chief work consisted in the construction and comparison of various standards and sources of light. The Violle-Siemens unit of light, viz., the amount radiated by 1 square centimetre of platinum at its melting point, proved to be very difficult of practical adoption. The use of block platinum was precluded by the difficulty of maintaining it in a state of sufficient purity during melting, and platinum foil was apt to tear at the critical moment. It was, therefore, decided to fix upon some temperature below the melting point, and to determine that temperature by the ratio of the total energy radiated to that transmitted by a layer of water contained in a vessel with plane-parallel quartz sides, a ratio which was found to be constant for a given temperature, and to vary rapidly on heating or cooling. The amount of radiation was measured in each case by means of a very delicate bolometer.

Strong sources of light, such as arc lamps, were compared with constant-current incandescent lamps by reducing the luminosity of the former by an Aubert sector, which can be adjusted to different angles so as to transmit a varying proportion of light through a circular area, the light being then uniformly distributed over the area by rapid rotation. Two illuminated patches were thrown side by side upon a screen, and the rotating sector adjusted till the boundary vanished. In the case of differently-coloured sources, the boundary was adjusted to its *greatest indistinctness*.

A great want seems to have been supplied by the arrangements for testing tuning-forks, upwards of 1,100 of them having been dealt with in the two years. A standard tuning-fork was made of polished steel, avoiding any rough surfaces or markings, which were found to encourage oxidation.

The properties of aluminium were investigated in a variety of ways, the chief object being the production of alloys capable of resisting weather, and suitable for divided circles. This work was carried out at the instance of the military authorities. Aluminium coated with brass rich in zinc was found to give good results.

A great deal of attention was given to the purification of mercury, platinum, and zinc. The former was obtained by electrolysis and distillation in a state of such purity, that the most delicate analysis could not find perceptible traces of impurities in a mass weighing 200gr. Platinum was obtained pure to at least 99·99 per cent. by converting into the double chloride of sodium and platinum. The impurities contained in the purest commercial zinc, consisting chiefly of lead, cadmium, and iron, were reduced from 1 in 3,000 to 1 in 100,000 by a process of combined electrolysis and distillation.

In the course of the last year, negotiations have been conducted and meetings held with a view towards adopting a uniform system of screw threads for the use of watch and clock-makers and other purposes of *feintechnik*. No final decisions have as yet been arrived at, and the movement has lately been deprived of one of its most strenuous and devoted advocates in the person of Dr. Loewenherz. But it is hoped that the demand will soon become an international one, and that it will become possible to execute delicate repairs anywhere, without the necessity of boring a new hole for every screw replaced.

The West-End Street Railway of Boston.—The gross earnings of this Company for the six months October, 1892 to April, 1893, show an increase of 7¼ per cent. over the corresponding six months of 1891-92 ; the net earning increase is no less than 34 per cent. This shows a reduction in the operating expenses from 79½ per cent. of the gross earnings to 74½ per cent., although the cost of removing snow was considerable greater than formerly. This decrease in operating expenses is due to the fact that this year 69 per cent. of the revenue car-miles were run by electric power and 31 per cent. by horses, while last year 38 per cent. were by electricity and 62 per cent. by horses ; and, also because, with motors cased in iron and running in oil, the of repairs needed are far less than with motors of the old kind which were exposed to the snow, water, and dirt.

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LEGAL INTELLIGENCE.

National Telephone Company (Limited) v. Harston.

Judge Ellison, in the Sheffield County Court, on Thursday, gave his decision in this matter (which was fully reported in our last issue). In iving judgment, his Honour said plaintiffs claimed £45. 10s. as the rent for telephones connecting defendant's establishments from December 1, 1891, until January 31, 1893. Plaintiff had paid into Court £29. 11s. 4d., the point in dispute being as to whether defendant was entitled to a reduction in terms, which came into force after the agreement. His Honour held that defendant was entitled to such a reduction, and gave judgment for plaintiffs for the amount paid into Court.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 12, 1893.

The Trolley Patents.—The fundamental patents recently issued to C. J. Van Depoele in behalf of the General Electric Company have been made the ground for a suit brought by that Company against several electric railway companies for an infringement of patent rights. It is probable that this is the initiation of an important legal battle which, possibly, may last as long and prove as interesting as that which has been fought for the past five or ten years over the invention of the incandescent electric lamp. It is difficult to believe, however, that the General Electric Company seriously anticipates securing a monopoly of the trolley, and it is, perhaps, rather a bluff on its part to put a better face on its financial condition than to secure any extension of its present control of the electrical business. In the recent financial crisis the stock of the General Electric Company was affected far more than that of any other electrical concern. It should not be thought, however, that this is a fair indication of the present condition of the General Electric Company, for it was undoubtedly due in a large measure to the general condition of the stock market, and to the fact that electrical securities are not yet taken in this country as the most desirable of investments.

Telephone Litigation.—The American Bell Telephone Company has filed a Bill in the United States Circuit Court of Pittsburgh against the McKeesport Telephone Company for infringement of its patent, dated January 30, 1877. The McKeesport Company recently began operations in the belief that the fundamental patents held by the Bell Company expired on January 20th and March 20th of this year. The Bell Company, however, claims that its fundamental patent, which does not expire until January 30, 1894, has been infringed by the McKeesport Company, and has asked the Court for a preliminary injunction. The case will excite widespread interest, as many other telephone companies are preparing to place instruments upon the market as soon as they feel assured that they will not immediately be enjoined by the Bell Company.

BOOKS RECEIVED.

"Electricity up to Date." By J. B. Verity. Enlarged. Third edition. Price 1s. 6d.

"Berechnung Elektrischer Maschinen." By E. H. Geist. (München: R. Oldenbourg.)

"Il Trasporto di Energia Elettrica da Tivoli a Roma." (Rome: Tipographia Elzeviriana.)

"Transactions of the American Institute of Electrical Engineers." May, 1893. (New York: The Institute.)

"Summer Tours in Scotland." By David MacBrayne. (Glasgow: David MacBrayne.)

"Transactions of the North-East Coast Institution of Engineers and Shipbuilders." Vol. IX., parts 4 and 5. London: Andrew Reid and Sons.)

"A Popular Treatise on Portative Electricity." By J. T. Niblett. Price 7s. 6d.

CORRESPONDENCE.

COOKING AND HEATING BY ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I can endorse Mr. Dowsing's remarks in his able letter on cooking by electricity, except in one particular. The conclusion at which he arrives, that electrical cooking can be performed at a cheap rate, comparing favourably with the cost of cooking by coal, is doubtless correct, and this fact cannot be made too widely known. This more especially among the electrical trade, as an idea seems to prevail that cooking takes "a frightful lot of current."

I am now making cooking apparatus which will cook a small leg of mutton, or a fowl, with about 5lb. potatoes and cabbage, with an expenditure of current equal to about two-thirds of a unit.

The following test with one of our ovens will show you some data, which, however, I think I can still improve upon:—

Time.	Temperature.	Current.	Pressure.
0	12° C.	9 amperes	100 volts
5 minutes	49° C.	9 „	100 „
10 „	108° C.	9 „	100 „
15 „	180° C.	9 „	100 „
20 „	225° C.	9 „	100 „
(The current reduced after 20 minutes).			
25 minutes	205° C.	3·5 amperes	100 „
30 „	195° C.	3·5 „	100 „

The temperature remains steady at 195°C. with 350 watts for three hours after this.

The exception which I have to make to Mr. Dowsing's figures refers to boiling water. He does not state the initial temperature of the water to be boiled, but simply says, "to boil a quart of water requires about 3½ amperes for ten minutes." This state of efficiency I have not been able to reach, nor can I understand how Mr. Dowsing can attain it, as it is beyond the theoretical efficiency calculated upon Joule's law. This law teaches us that 1 watt acting for 1 second developes ·238 calorie, or, in other words, raises 1 gramme of water 1°C. in 1 second. Taking 1 pint of water to weigh 1¼lb., and the initial temperature of water at 15°C., we can calculate that 1,000-watts will boil such water (or raise the temperature by 85°C.) in 3·383 minutes. I am now selling copper kettles which will perform this operation at an expenditure of current which equals 1,000 watts for 3·8 minutes per pint, and which gives about 90 per cent. of theoretical efficiency. More than this I have not been able to achieve.

As it has not yet been publicly stated, I may mention that my method of manufacturing electrical cooking and heating apparatus (as carried out by my firm, the General Electric Company) differs essentially from the American or Crompton's methods (which I myself first introduced into this country during the Exhibition at Crystal Palace), and I claim that I have thereby gone an important step in advance.

The insulating and refractory material is a cement which can be applied to the surface to be heated without baking or subjecting to heat. I have found that enamel, which is being used in the American method, cracks, and thereby reduces the protection aimed at, viz., that of excluding atmospheric oxydisation. The cement has no deteriorating influence on the resistance wires, allows the use of an extremely thin film of insulating division between such wires and the surface to be heated, and thus renders the apparatus very durable and efficient.

I note that in your Editorial Notes you remark that you hope the price of the apparatus will soon be reduced. I have already taken steps to accomplish this object, and have no doubt that the apparatus will in time be sold at prices within the reach of everybody. I have found great difficulty in getting the right articles made suitable for my method of manufacturing, but this is gradually being overcome, and if the demand is large enough, which I hope it will be, the cost of manufacturing, and consequently the selling price, will be materially reduced.—Yours, &c.,

G. BINSWANGER.

71, Queen Victoria-street, London, E.C., May 23, 1893.

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TO THE EDITOR OF THE ELECTRICIAN.

SIR: The controversy on this matter, which is at present going the round of the press, has developed into a form which is neither useful nor instructive, and has no bearing on the actual question involved.

Mr. Dowsing, in your last issue, tries to compare the cost of electrical heating with that of coal, a comparison which is impossible, as the conditions required are totally different. Mr. Dowsing gives no exact figures to calculate from as to the total available heat per ampere hour, and it is possible that the heating apparatus at present used may be greatly improved; the first apparatus designed can hardly be considered as final, although Messrs. Crompton may be fairly credited with the first practically successful attempt to utilise electricity for domestic heating purposes. Taking Mr. Dowsing's own figures, with electricity at 5d. per unit, it requires about 3½ amperes for ten minutes to boil one quart of water, the cost being one-third of one penny. With the water at an initial temperature of 62°F. this gives an expenditure of 375 units of heat in useful work, a cost rate of 1125 units for one penny. The only fuel which can compare with electricity is ordinary coal gas, which can be used under the same conditions and with the same regard to economy in small and irregular work. One cubic foot of coal gas, as supplied in London, has a total heating power of 660 units, and of this, over 600 units are obtained in actual work in many commercial forms of bath heaters; in boiling a small kettle over an atmospheric burner, the average duty in practice will not exceed about 400 units, *i.e.*, less than two-thirds the total theoretical work. If we allow a further margin, and reduce this to 375, one cubic foot of London gas will give at least the work of 3½ amperes for ten minutes, and three cubic feet, costing one-tenth of a penny, will do the work specified by Mr. Dowsing as costing one penny for the electricity used. No doubt, each will have its own place, and will fill certain special requirements, but it is certainly a mistake to attempt to prove that electricity is at present a cheap source of heat. No doubt, the duty actually obtained from coal gas is very much higher than it was at first, and electricity has the very great advantage that its practical application is in the hands of trained experts, and has been so from the first; possibly, no industry in the world has so large a proportion of competent manufacturers and first-class workmen, who understand both the theory and practice of their work.

The application of coal gas as a fuel, on the contrary, has been under a cloud for years. Discouraged by the old proprietary companies, and hampered, as it has been and still is, by want of knowledge of the simplest natural laws on the part of most of the men who have to make and fix the apparatus, it is only now beginning to emerge from a state of chaos; but when it has been thoroughly established on a proper scientific basis, the manufacturers of coal gas will have no more to fear for its future than they have now from the beautiful old moderator lamps, which are so charming and so expensive, in our drawing-rooms and picture galleries. All are not fortunate enough, or rich enough, to have electric lighting, or to put in special ventilators for the removal of the products of combustion. When the purveyors of either gas, electricity, or moderator lamps assume the possession of perfection and infallibility, they only lay themselves open to attacks which are not always tempered with justice or discretion, and which cause a very unnecessary ill-feeling.—Yours, &c.,

Warrington, May 24th, 1893. THOS. FLETCHER, F.C.S.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to Mr. Dowsing's letter in your last week's issue, and to your editorial notes thereon, I beg to point out that what Mr. Dowsing states as to the time taken to boil one quart of water with 3½ amperes at 100 volts must be quite incorrect. The theoretical time required to boil the water alone is 18 minutes from 20°C., and there is the metal of the kettle and the enamel, &c., together weighing several pounds, to be heated in addition, so that at least 20 minutes will be required, even if the apparatus has an efficiency of 100 per cent., which it certainly has not.—Yours, &c.,

LESLIE MILLER.

TRADE NOTES AND NOTICES.

The 1893 Edition of "THE ELECTRICIAN" Electrical Trades Directory and Handbook is NOW READY. This useful book contains over 1,000 pages, and several new and handy features have been added. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

TENDERS INVITED.—The Borough of Falmouth Urban Sanitary Authority are desirous of receiving offers from companies or firms willing to undertake the introduction of the electric light in the Borough on their own responsibility.

——— The Woolwich District Electric Light Company (Limited) invite tenders for laying cast-iron pipes with inspection boxes, &c., for the mains under the footways of certain streets in the Woolwich District. Specifications can be obtained of Messrs. Pritchetts and Gold, Soho-square, W.

TENDERS ACCEPTED.—The Brighton Corporation have accepted the tender of Messrs. Goolden and Co. for the supply and erection at the electricity works, North-road, of a central-station switchboard and apparatus, the amount of the tender being, as will be seen by the list, less than one-fourth that of the highest :—

Fowler, Lancaster and Co. (Limited), Birmingham	£3,459	0	0
Messrs. Laing, Wharton and Down, London	3,388	0	0
Gulcher Electric Light and Power Company (Limited), London	2,480	0	0
Messrs. Johnson and Phillips, London	2,414	6	0
Poole and White (Limited), London	2,248	12	6
Crompton and Co. (Limited), London	2,231	0	0
Latimer Clark, Muirhead and Co. (Limited), London	1,750	0	0
Thames Ironwork and Shipbuilding Company (Limited), London	1,300	0	0
Siemens Bros. and Co. (Limited), London	1,230	0	0
Messrs. Goolden and Co., Harrow-road, London (accepted)	800	0	0

——— The Governors of the Killarney District Lunatic Asylum have accepted the tender of the Killarney Electric Light Company (Limited) for the installation and supply of electric light to the asylum. The installation is to consist of 324 16-c.p. lamps, and the amount of the tender is £185 per annum.

——— The County Council of Huddersfield have accepted the following tenders :—Mr. A. Sykes, Turnbridge, for the supply and fixing of electric light fittings at the lighting station, St. Andrew's-road; Messrs. Calvert and Co., for the supply of cast-iron exhaust pipes for the boilers at the same station; Messrs. Liversedge and Co., for the supply and fixing of a lightning conductor to the chimney.

——— The Great Northern Railway Company have accepted the tender of Messrs. Johnson and Phillips for the supply of Brockie-Pell arc lamps and accessories for their Holloway electric light station.

CHANGE OF NAME.—By sanction of the Board of Trade, the Electricity Supply Corporation (Limited), of 12, Maiden-lane, W.C., will in future be known as the Charing-cross and Strand Electricity Supply Corporation (Limited).

COMMERCIAL CABLE COMPANY.—This Company issue a well-illustrated pamphlet in connection with the World's Fair at Chicago. Included in the list of illustrations are photographs of the many offices of the Company throughout Great Britain and America.

AGRICULTURAL HALL, LONDON.—We have frequently commented upon the absence of the electric light in this large building, and we shall, doubtless, shortly learn that steps are being taken to instal the light, as the London County Council refused its consent to the letting of spaces under the galleries during the recent Horse Show unless the electric light was used. As a consequence, the spaces, which would otherwise have brought in a considerable rentage, were unoccupied.

THE TRENT GAS ENGINE COMPANY.—This firm have selected, as a method of advertising and introducing their specialities to probable purchasers, a weather almanack, copies of which can be obtained on application to the Company's Nottingham offices.

LONDON AND LANCASHIRE ELECTRIC AND GENERAL ENGINEERING COMPANY (LIMITED).—This Company, in notifying the appointment of Mr. C. N. Russell as their engineer and manager, announce that several important additions to their manufacturing plant have recently been put down, and they are now able to promptly execute orders for Weston dynamos, arc lamps, and general electrical apparatus, as well as metal spinning and light and heavy general engineering.

THE ELECTRO-HARMONIC SOCIETY.—The balance-sheet is issued of this Society, which shows the total number of members at the close of the seventh season at 338, comparing with 155 members in the first season. Application forms for new members can be

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obtained of the hon. sec., Mr. H. Alabaster, Brockenhurst, Therapia-road, Honor Oak, S.E.

TRAIN DEPARTURE INDICATOR.—We give an illustration of a signal apparatus made by the Allgemeines Elektricitäts Gesellschaft, of Berlin, and designed to prevent the confusion which prevails at many railway termini (especially on the Continent), owing to passengers not being able to readily ascertain the time of departure of their trains. These indicators are intended to be placed in conspicuous positions at the station, and show the destination and time of departure of the train, while a warning is given by the ringing of an electric bell inside the case at intervals of a few minutes before the time of departure. Doubtless railway

officials would be spared incessant questioning and worrying were apparatus of this kind in more general use.

BEDFORD.—A deputation last week waited on the Town Council to protest against the electric light undertaking being placed in the hands of a company, and urging the retention of the powers of the Provisional Order by the Council. A petition signed by 204 ratepayers was presented. Ultimately the petition was referred to a special meeting of the Council for consideration.

DOLGELLY.—The Local Board have received a bill from the local Electric Lighting Company claiming £2,000 for damage alleged to have been done to their lamps. The Board refused to pay the bill.

DOVER.—A satisfactory settlement has been come to between the Town Council and the Brush Company in reference to the lighting arrangements for the town, but as the time for the commencement of operations has expired, a further extension for three months has been agreed to.

DUBLIN.—The branch office of Messrs. Woodhouse and Rawson United (Limited), which has been established here for some time, is about to be closed. The Edison and Swan United Electric Light Company are opening extensive premises in Dawson-street as an Irish depôt for the exhibition and sale of their manufactures, under the supervision of Mr. Boucher.

ELECTRICAL TRADES' UNION.—A meeting of union and non-union men employed in the electrical trades was held on Saturday last at the Black Boy Inn, Newcastle. Very few persons were present. Mr. W. T. Gooday, the general treasurer, addressed the meeting on the eight hours question.

FALKIRK.—Mr. T. Blackadder, of Messrs. Blackadder Brothers, Garrison Foundry and Engine Works, Falkirk, has introduced the electric light into his mansion, the necessary plant being manufactured by the firm. The installation includes storage batteries.

FIRES.—On Wednesday morning the premises of Messrs. Taylor and Tucker, art metal workers, at Harlesden, were burnt to the ground. The damage to the building (of which the walls only remain) and the contents is estimated at £10,000.——On Wednesday some damage was caused to the Woodhouse and Rawson Company's works at Hammersmith by a fire which occurred at the Kensington Stores.

GLASGOW.—The extensive premises of the British Linen Bank, Queen-street, Glasgow, have been completely installed with the electric light by Messrs. Anderson and Munro, of Bothwell-street.

HOTEL LIGHTING.—The first of the Dundee hotels to be lighted electrically is Mather's Hotel, Whitehall-street, Dundee. The work will be carried out by Messrs. Maxwell and Co. The Royal Hotel is to be similarly lighted as soon as the alterations are completed.——At Windermere, Riggs', The Old England, Crown and Bellsfield Hotels have been lighted by electricity, and it is expected that the public lamps will be in working order almost immediately.

HOUSE LIGHTING.—Mr. John Paddons has recently installed the electric light at his residence, St. Sidwell's, Sydenham Hill, S.E., the light being used throughout the house and stables in the rear. The fittings, which are of exceptionally artistic design, were supplied by Messrs. Evered and Co. and Messrs. Richard Crittall and Co.

HUDDERSFIELD.—In connection with electric lighting, a special sub-Committee of the County Council have visited Sheffield, and have examined the system of electric lighting in that city. Mr. J. A. Crowther has been appointed mechanical engineer in connection with the electric lighting department. Tenders have been accepted by the Council, particulars of which will be found in a previous column. At the last meeting a question was asked as to why the sub-Committee had found it necessary to alter the arrangements previously come to with the Brush Company, and Councillor Garton, in explanation, said that, at the time those arrangements were made, the Committee prepared a schedule of prices. They had received more applications for the electric light than had been anticipated, and when the Committee applied for the additional supply, the Brush Company asked more than the Committee considered they were entitled to by this schedule of prices. The plant originally put down was not sufficient for the demand upon it, although sufficient to start operations with. The report of the Committee was adopted.

LEICESTER.—The Midland Railway Company are putting down a Dowson gas plant in connection with their electric lighting installation at the new Leicester Station. Crossley gas-engines are to be used.

SHEFFIELD.—The Sheffield Electric Light and Power Company (Limited), having now nearly completed the laying of their underground mains throughout the compulsory lighting area, have opened a large show room for electric light fittings and apparatus at 27, Church-street, Sheffield, under the charge of Mr. M. B. Cotterill.

SHREWSBURY.—As mentioned in our last issue, the Local Gas Company has intimated to the Town Council their intention to increase the price of gas supplied to the public lamps. A long discussion upon the subject took place at the last meeting of the Council, during which it was pointed out that the Gas Company had enjoyed great prosperity for many years, and that they were thus pursuing an unwise policy in exacting higher rates for the gas than previously, because they were unable to keep up the statutory 7½ per cent. dividend. Mr. Barker, the Chairman of the Gas and Lighting Committee, said that the Committee would undertake to give the subject of electric lighting their best attention.

TRAMWAY LIGHTING.—The Dundee Tramway Company have commenced a series of experiments in lighting their cars by electricity. Paraffin lamps are at present used, and we understand that the question of substituting the electric light is only one of arrangement between the Gas Commissioners and the Tramway Company as to the terms for charging the batteries.

WATFORD.—The Local Board have finally decided to apply for an Electric Lighting Provisional Order.

WINDSOR.—Messrs. Laing, Wharton and Down have appointed Mr. Dunning, of 6, Clifton-villas, Devereux-road, Windsor, their resident representative. Considerable extension of private electric lighting has recently taken place in the district.

WOLVERHAMPTON.—The Lighting Committee have met to consider the applications for the post of electrical engineer in connection with their electric lighting scheme, and the names of Mr. Baynes, of Bradford, and Mr. Lewis, of Hull, are those from whom the final selection will be made.

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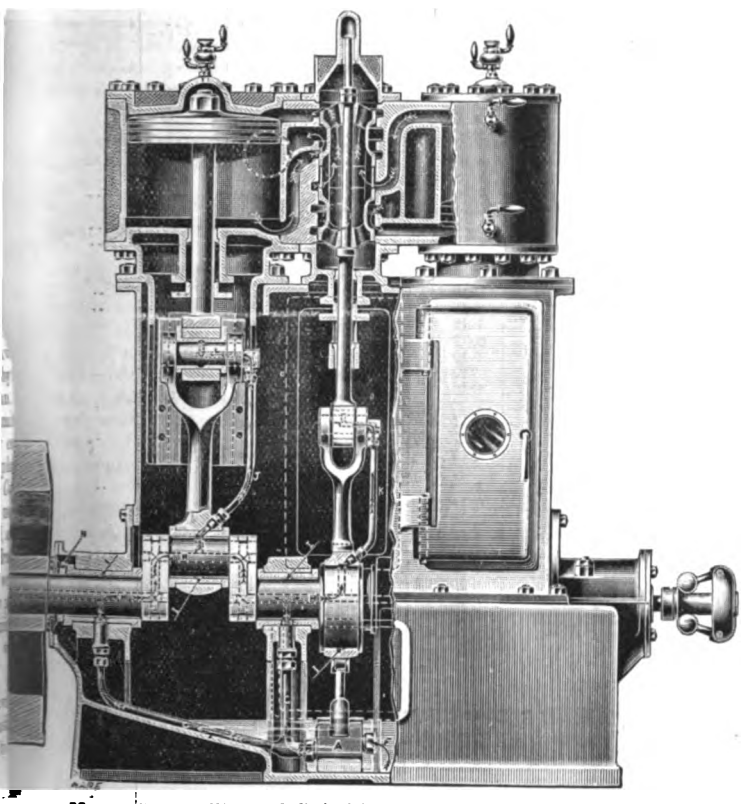
MESSRS G. E. BELLISS AND Co.—We have to acknowledge the receipt of a handsome catalogue from this firm, containing a number of excellent illustrations of the specialities for which they have attained well-merited success. Among the numerous illustrations included in the catalogue will be found electrical fans, gas compressers, and a variety of electric light engines of several types, including those supplied for the Cunard vessels. On pages 12, 13A, and 13B a full description is given of the Belliss patent double-acting, high-speed noiseless engine, for which, among other advantages, simplicity, durability, economy and steady running are claimed. The engines described in the list are suitable for many purposes, and on pages 43, 44, and 45 are shown illustrations of special steam-launch machinery, for which Messrs. Belliss and Co. have received many orders. The catalogue consists of 60 large 4to pages, and reflects credit alike upon the compilers, engravers and printers. How much good engravings contribute to the success of



Messrs. G. E. Belliss and Co.'s "Crescent" Type Compound Double-acting High-speed Noiseless Engine.

an engineering catalogue was never better shown than in the list under review, and Messrs. Hare and Co. have seldom produced better work, as will be seen on reference to the illustration we give above.

COMPANIES' MEETINGS AND REPORTS.

Telephone Company of Ireland (Limited).

The fourteenth ordinary general meeting is to be held at the offices, Commercial-buildings, Dame-street, Dublin, to-morrow (Saturday), the 27th inst., at 12 noon.

Included in the business of the meeting will be the consideration and, if approved, the passing of a resolution as follows:—

"*That the provisional agreement submitted to this meeting for the transfer of the undertaking of this Company to the National Telephone Company (Limited)—which agreement is dated May 11, 1893, and made between this Company of the one part and the National Telephone Company of the other—be and the same is hereby ratified, and that the Directors be and they are hereby authorised to carry out the said agreement, with such modifications (if any) from time to time as they may deem expedient.*"

In their report the Directors state that during the year there has been an increase of 63 subscribers, and that the account shows a balance to the credit of net revenue sufficient to pay the arrears of dividend upon the preference shares and a small dividend upon the ordinary shares, but that, owing to the necessity for a large expenditure of capital account, the Directors are unable to recommend that any portion of the earning shall be distributed amongst the shareholders. It is proposed to renew the whole of the internal arrangements of the Company's exchanges in Dublin, Cork, Limerick, Dundalk and Drogheda, and to replace the present switch-boards by others of the latest construction. Owing to the fact that the preference shares of the Company which were offered in January, 1890, and also that the debentures offered in July of the same year, were not taken up by the shareholders, the Directors were compelled to incur a large expense, as was shown in the accounts for 1891, and they have been forced to the opinion that an amalgamation with the National Telephone Company would be most advantageous in the interest of the shareholders. Accordingly, the agreement above referred to has been entered into, subject to the shareholders' approval. By this agreement the National Company offers £81,300 for the assets of the Telephone Company of Ireland, and walve any claim to participate in the assets of the Company in respect of the moiety of the ordinary share capital to which they are entitled. These terms the Directors consider fair, and recommend their acceptance. After paying off the debentures and preference share capital (amounting to £61,197), £20,103 would remain for division among the ordinary shareholders, subject only to the arrears of preference divided to December 31st last, and the expenses of liquidating the Company. A large proportion of the preference shareholders have consented to the arrangement with the National Company, on condition that they receive 20s. per share in full discharge of principal and arrears of dividend. Under the agreement referred to with the National Company the interest upon the debentures, and the dividend upon preference shares accruing since January 1st last, are to be borne by the National Telephone Company. Alderman Dillon, Chairman of the Company, retires, and is eligible for re-election; and the auditor, Mr. J. M. Kean, also seeks re-election.

Reuter's Telegram Company (Limited).

The following is the Director's report to be presented at the twenty-ninth ordinary general meeting of the shareholders, to be held at the offices, 24, Old Jewry, London, on Wednesday next, the 31st inst., at 12 noon:—

The Directors beg to report that the net profits for the year ended December 31st last, after payment of current expenses, and deducting rebate or unexpired subscriptions, amount to £3,567. 0s. 10d., including £98. 17s. 4d. brought forward from the last account. In accordance with the Articles of Association, which authorise the appropriation of the reserve for the purpose of equalising dividends, the Directors have transferred the sum of £1,500 from that fund to the profit and loss account, making the total amount available for distribution £5,067. 0s. 10d. The usual interim dividend of 2½ per cent was paid in October last, and the Directors now declare a further dividend of 4s. per share, making a total distrbution, free of income-tax, of 5 per cent. for the year. This will absorb £4,814. 1s. 2d., and leave a balance of £252. 19s. 8d. to be carried forward. The dividend warrants will be payable on the 3rd proximo.

A resolution will be submitted to the meeting authorising the Directors to augument the annual grant made to the Officers' Life Insurance and Superannuation Fund established in 1881, in order that effect may be given to the portion of the scheme dealing with superannuation.

In conformity with the Articles of Association, Mr. Frederick J. Griffiths retires from the Direction, but, being eligible, offers himself for re-election. The auditors, Messrs. Welton Jones and Co., also offer themselves for re-election.

CITY NOTES, &c.

ALLIANCE ALUMINIUM COMPANY (LIMITED).—A meeting is to be held at Messrs. Powell and Burt's, 28 and 29, St. Swithin's-lane, London, E.C., on June 26th, at 12 noon, for the purpose of receiving the liquidator's account of the winding up.

BOY MESSENGERS AND ELECTRIC CALL COMPANY (LIMITED).—Notice is given that the creditors of this Company (in voluntary liquidation) are required to send their names and addresses, and the particulars of their debts or claims, to the liquidator, Mr. Montague Pawson, 58, Coleman-street, London, E.C., on or before June 5th.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended May 21st were £794, as against £766 for the corresponding period of last year, being an increase of £28. The total receipts for the half-year amount to £17,735, against £16,374 in the corresponding period of 1892, being an increase of £1,361.

MARTINY (LIMITED).—Notice is given that the first annual drawing of the Five per Cent. First Mortgage Bonds of this Company will take place at the offices, 37, Lombard-street, on June 30th, at 3 p.m., when bonds to the amount of £2,000 will be drawn.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—This Company give notice that the coupons due on June 1st on the £50,000 Five per Cent. Registered Debentures (Bonds 1 to 5,000) will be paid on and after that date at Messrs. Prescott's Bank, 50, Cornhill, or at the Royal Bank of Scotland, 123, Bishopsgate-street (Within), E.C. The coupons must be left at the bankers three days for examination.

NATIONAL TELEPHONE COMPANY (LIMITED).—Letters of allotment and regret have been posted in respect of £273,523 of the Four and a-Half Per Cent. Debenture Stock, which was recently offered to the ordinary shareholders of the Company.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee have appointed Tuesday next, the 30th inst., a special settling day in the following securities, which are also to be quoted in the Official List:—Charing Cross and Strand Electricity Supply Corporation (Limited), 20,510 shares (Nos. 1 to 6, 215 to 718, and 10,001 to 30,000); Pacific and European Telegraph Company (Limited), £100,000 Four per Cent. Guaranteed Debentures (Nos. 1 to 1,000).

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WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended May 19, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,680.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED.)—The receipts for the two weeks ended May 15th were £4,000, as compared with £2,663 for the corresponding period of last year. January receipts estimated at £5,568, realised £5,647.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name	Previous Week's Price, May 17.		Price Wednesday, May 24.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May 24.	
										Highest	Lowest
			TELEGRAPHS					£ s. d.			
£1,247,720	Stock	12/6	Anglo-American	50½	51½	50½	51½	5 6 10	Jan., Apr., July, Oct.	51½	50½
£2,876,140	Stock	25/0	Do. Preferred	91½	92½	91½	92½	5 18 11	" "	93	92½
£2,876,140	Stock	5/0	Do. Deferred	11¼	11½	11¼	11½	..	" "	12	11½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	101	104	101	104	3 16 11	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11⅜	12½	11⅜	12½	5 6 1	Mar., June, Oct., Dec.	12 1/16	12
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107	111	107	111	4 10 1	June and December	..	..
$7,716,000	$100	$13½	Commercial Cable Capital Stock	140	150	140	150	4 13 4	April and October	..	..
16,000	10	8/0	Cuba Submarine	11½	12½	11½	12½	6 8 0	February and August	12 3/16	..
6,000	10	10%	Do. Preference 10%	18½	19½	18½	19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2⅜	3½	2⅜	3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅜	12	11½	11⅝	5 19 2	Jan., Apr., July, Oct.	11⅝	11½
400,000	10	2/6	Eastern	15⅜	15⅝	15½	15⅝	4 3 10	" "	15 5/16	15 1/16
70,000	10	6%	Do. 6 per Cent. Preference	16½	17	16⅜	17	3 10 7	" "	16⅜	..
£1,294,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	113	116	113	116	3 9 0	May and November	114½	113½
£105,990	100	5%	Do. 5 per Cent. Debentures 1899	108	111	108	111	4 10 1	February & August	109½	108⅝
250,000	10	6%	Eastern Extension	15⅝	16	15⅝	15⅞	4 8 2	Jan., Apr., July, Oct.	15⅝	15½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114	117	114	117	3 8 5	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	104	107	103	106	4 14 4	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb., 1900	103	106	103	106	4 14 4	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101	104	101	104	3 16 11	February & August	..	..
180,227	10	2/3	Globe Telegraph and Trust	9⅝	9⅞	9⅝	9⅞	4 11 2	Jan., Apr., July, Oct.	9⅞	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	15⅝	15⅞	15⅝	15⅞	3 15 7	" "	15⅞	15½
150,000	10	7/2	Great Northern	19	19½	19¼	19⅜	4 6 11	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	41	43	41	43	5 16 3	May and November	..	..
38,348	10	4/0	London Platino-Brazilian xd	4	6	4	6	6 13 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
10,802	8	4/0	Reuter's	7	8	7	8	..	April and October	..	..
3,381	£100 Cert.	30 0	Submarine Cables Trust 6%	120	125	119	124	4 16 9	" "	121	..
15,609	10	5/0	West African Telegraph	5½	6½	5½	6½	7 13 10	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100	103	100	103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	2	3	2	3	..	January and July	2⅞	2⅝
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	June and December	..	..
88,321	10	6d.	West India and Panama	1¼	1½	1⅜	1⅝	..	" "	1 7/16	1⅛
34,563	10	6%	Do. 6 per Cent. 1st Preference	11½	12	11½	12	5 0 0	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9½	10¼	9½	10½	5 14 3	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	108	111	108	111	4 10 1	June and December	110	..
64,242	£5	4 6	Western and Brazilian xd	7⅛	8	7⅛	8	4 13 11	May and November	7⅞	..
33,129	7½	4,6	Do. 5 per Cent. Cumulative Preferred xd	5⅞	6½	5⅞	6½	6 0 1	" "	6½	6½
33,129	7½	4/6	Do. 5 per Cent. Deferred	1⅞	2⅛	1⅞	2⅛	..	" "	2	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	107	110	106	109	5 10 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106	109	106	109	5 10 1	" "	..	..
$1,836,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	..	..
£173,100	£100	6%	Do. 6 per Cent. Sterling Bonds	101	104	100	103	5 16 6	March & September	101	..
			TELEPHONES								
40,000	£5	10/0	Chili Telephone (fully paid)	3	4	3	4	..	..	—	—
22,500	15/0	1½d.	Consolidated Telephone Const. & Maintenance	1 3/16	1 5/16	1 3/16	1 5/16	..	May and November	..	..
20,000	£1	4½d.	Oriental (11s. paid)	⅜	½	⅜	½	7 18 2	Yearly	..	..
454,747	5	2/6	National	4⅝	5⅜	5	5½	5 14 3	June and December	5½	5
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref	15	15½	15	15½	4 17 6	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14½	14⅝	14½	14⅝	4 1 4	" "	14⅝	14½
90,950	5	6⅝d.	Do. 5% Non-Cumulative 3rd Pref (£3 paid)	5½	5⅝	5½	5⅝	..	..	5⅝	5⅜
726 477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	113	116	113	116	3 17 7	January and July	113⅜	..
48,000	£10	..	New Telephone, Limited (£4 paid)	..	..	..	..	..	..	..	..
58,000	5	1/0	United River Plate	2	3	2	3	..	January and July	..	..
	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (fully paid)	12	12½	12	12½	..		..	..
20,000	£10	..	Do. 6 per Cent. Preference (£4 paid)	12½	13	12½	13	..	..	12⅞	12¼
19,900	£5	..	Electricity Supply Co. of Spain	..		..		..		—	—
£150,000	£5	..	Electricity Supply Company Ordinary	..		..		..	.	..	—
£47,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	..	..	—
8,332	£5	..	House to House Electric	1½	2½	..		..	—	—	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully pd.)	5⅜	5⅞	..		..	..	..	—
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	6	6½	..		..	January and July	..	—
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4½	4⅝	4½	4⅝	..	..	..	—
10,000	£5	5/0 '92	Do. (fully paid)	6⅜	6⅝	6⅜	6⅝	..	..	..	—
111,000	5	..	London Electric Supply	⅞	1⅛	⅞	1⅛	..	—	..	..
43,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6	6½	6½	6⅝	2 19 3		6½	6⅜
£50,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, & £40)	102	105	103	106	4 14 4	June and December	..	..
16,318	10	..	Notting Hill Electric Lighting (fully paid)	5	6	5	6	..	—	..	..
18,680	£5	9½%	St. James' and Pall Mall	7½	8	7½	8	..	—	7⅞	7⅝
7,900	£5	7%	Do. 7% Preference	8	8½	8	8½	4 2 4	—	..	..
42,858	6	2/0	Westminster Electric Supply (fully paid)	5½	6	5¼	5½	3 0 10	—	5⅝	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/6	Brush Electrical Engineering	3	3½	3⅛	3⅜	..	—	3⅜	3 1/16
69,996	2	6%	Do. 6 per Cent. Preference	2⅛	2⅜	2⅛	2⅜	5 1 1	—	2⅜	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	108	110	108	110	4 1 0	..	109½	108½
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼	5⅜	5¼	5⅜	6 1 9	January and July	5⅜	..
12,139	5	..	Edison and Swan United	..		..		..	—	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	1⅜	2⅛	..		..	.	..	..
45,000	10	12/0	Electric Construction	2⅛	2⅜	2⅛	2⅜	..	.	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	⅛	⅜	⅛	⅜	—	—	1/16	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1	2	1	2	..	.	..	..
50,000	10	15/0	India Rubber, Gutta Percha & c., Works	23	24	23	24	5 4 2	February & August	23½	23
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	103	102½
11,334	£10	6/4	International Okonite Limited Ordinary	2½	3½	2½	3½	..	..	..	..
11,334	£10	8/0	Do. Preference	..		..		..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	5/0	6/0	5/0	6/0	..	..	..	..
78,949	5	4/2⅞	Swan United (£3. 10s. paid)	3	3½	3	3½	10 0 0	May and November	..	..
37,350	12	24/0	Telegraph Construction and Maintenance	30	32	30	32	5 12 5	March and July	31⅜	30
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102	105	102	105	4 15 3	January and July	104½	103½
..	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	..		..		..	—	..	—
..	£5	..	Do. Preference (fully paid)	..		..		—	—	..	..
			RAILWAYS AND TRAMWAYS.								
63,000	£10	..	City and South London Railway	..		..		..	..	..	..
600,000	Stock	2%	Do. Stock	37	39	37	39	2 17 8	May and November	7½	—

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 785.—Vol. XXXI. FRIDAY, JUNE 2, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

The new engineering and electrical laboratories of University College, which were "opened" by the Duke of Connaught on Monday last, will, when they are equipped and ready for use, form an important addition to the means for teaching the scientific principles of engineering. An article by Dr. Fleming and Hudson Beare in a descriptive pamphlet, as well as a paragraph in a circular of the Department of Applied Science and Technology, distinctly state that "it should be clearly understood that the education given in this Department of the College is not intended to supersede such necessary practical training as can only properly be acquired in the workshop or factory." The buildings, which are not yet completed, will contain a considerable number of different rooms and laboratories. The arrangements appear to be most carefully worked out, both as to the accommodation for a great variety of work and in the details of the fittings. The laboratories give every promise of being worthy of a College which was the first to teach the science of engineering, and the first in this country to establish, under Prof. Kennedy, an engineering laboratory.

Useful as the results of a properly-directed course of applied science may be to the students for whom these laboratories are primarily intended, we may confidently expect that valuable original work will be done, not in the ordinary course of teaching, but by the professors and their staff. Experiments carried out in collaboration with other departments—for example, the relation between the magnetic hysteresis and permeability, and the mechanical properties of iron under stress—together with the chemical constitution of the specimens, is a subject which might be most usefully dealt with in such a laboratory.

The "elevated tone," to use the words of an engineering contemporary, that Mr. J. B. Thacher, Chairman of the Awards Committee of the Chicago Exhibition, has endeavoured to impart to the ever-burning question of exhibitors' medals, &c., does not appear to be appreciated in the proper quarter. A Reuter's telegram, dated Chicago, May 27th, reads as follows:—

> The controversy over the system of giving awards at the World's Fair has taken a surprising turn. The Commissioners of the foreign countries represented have decided to enter into competition amongst themselves, to establish a board of jurors independent of those in the American section, and to issue diplomas without regard to Mr. Thacher, President of the Bureau of Awards. The position is very embarrassing. The awards granted by the foreign Commissioners, who have now withdrawn, will, under present circumstances, be the only evidence of international competition, for the South American Republics are expected to join the movement. Mr. Thacher will, therefore, be left with nothing but the American section to deal with.

The scheme, which has added yet another to the many unedifying squabbles connected with the Chicago Exhibition, in so far as it is a distinct departure from the discredited system hitherto in vogue, deserves the support of all who desire to see an end put to the imposture of granting certificates of industrial virtue without inquiry; and we trust that a half-way house will yet be found between the Thacher and the jury system. The proposal of the Chairman of the Awards Committee was that each and every exhibitor should be given a bronze souvenir medallion as an evidence of participation in the Exhibition, and that deserving exhibitors should receive a report, signed by an expert judge, setting forth the merits of the exhibits, without "odorous comparisons." Against the Thacher scheme, of course, objections may be made; and unless all the experts be men entirely above suspicion, not only of corruption but of favouritism, the results would be even worse than those of the jury system; but no doubt the real *raison d'être* of the present uprising is that we are not as yet educated up to the height of subordinating the commercial advantage of the individual to any other consideration.

According to a telegram, dated Chicago, May 31st, Mr. Thacher has partially yielded to the pressure brought to bear upon him by the foreign exhibitors, and has modified his rules governing the question of awards. He has addressed a letter to the foreign Commissioners, informing them that, in accordance with their request, two or more judges or examiners would be appointed to inspect individual exhibits.

A decision recently given in an action brought by the Edison Company against the Equitable Life Assurance Company of New York is one that we should very much like to see repeated in this country. The owners of a patent sought to recover damages against a private user who happened to be in possession of certain electric light fixtures covered by their patent. The judge held that as the plaintiffs had for eleven years acquiesced in the alleged infringement, they had forfeited all right to recover. The raking-up of forgotten patents and the annoyance of unwitting private infringers are two abuses which should be rendered impossible whenever our own Patent Code again comes up for revision.

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Messrs. J. H. Holmes and Co., of Newcastle, have sent us a report by Prof. Kennedy on their dynamos, which we described last week. The figures tend to corroborate the report which has been already published; the combined efficiency being 85·6 per cent. instead of 86·04 per cent., and the steam per electrical horse-power 20·3 instead of 21·66lb. The rise of temperature of the armature was given as 44·7°F. in the previous report, but Prof. Kennedy, by inserting a thermometer with a small bulb well into the end of the armature, found a temperature of 132·5°F., showing a rise of 72·0°F. after a six hours' run. When a temperature limit was first included in the Admiralty specification, contractors were left in ignorance as to the mode in which the temperature would be measured, or, rather, in which an attempt would be made to measure the temperature of some part of the machines. Between the laying of a thermometer against the outside of an armature, with the application, perhaps, of a piece of waste outside, and the measurement of the resistance of the armature circuit, there is room for a great difference. Nothing could be more easy and less accurate than the former, while exactly the reverse might be said of the latter. Prof. Kennedy's plan of probing with a small thermometer is an excellent one, but perhaps dynamo builders who find a difficulty in keeping their armatures cool will endeavour to avoid leaving a suitable hole for such a test. The obvious result would be that a demand should be made in specifications for such a hole, if it is proposed to adopt this method. Some curves giving the efficiency for different loads, the "Willans law" lines of steam consumption, and the steam per E.H.P. hour and I.H.P. hour, accompany Prof. Kennedy's report, but we received them yesterday too late for publication.

Mr. J. Erskine Murray's determinations of the electro-chemical equivalent of zinc, which are given elsewhere in the present issue, constitute a useful contribution to our knowledge of natural constants. The difficulty in obtaining a coherent deposit of many metals that can be separated by the electrolysis of their aqueous solutions, makes the direct comparison of their equivalents no light task, especially when, as in the case of zinc, the high heat of combination of the metal, and the ease with which it is superficially oxidised, have to be considered and provided for. It is interesting to note that the best-looking deposits were got when the cathodes were used soon after they had been polished, indicating that superficial oxidation, scarcely discernible by any other means, occurs within a short period after cleaning. The known difference of the ease of attack of pure and commercial zinc suggests a question as to the quality of the zinc used by Mr. Murray for his plates. The purest metal that has been hitherto prepared is that produced by the fractional distillation *in vacuo* of approximately pure zinc contained in a glass combustion tube—an operation less formidable than it sounds. Should zinc, contaminated with such an impurity as lead or cadmium, have been used, the occurrence of the light brownish film observed on the parts of the plate bearing no appreciable deposit would be explained, even assuming that the electrolyte consisted originally of pure zinc sulphate.

Another result of importance is the possibility of calculating the atomic weight of zinc from Mr. Murray's figures. The comparison has fortunately been made with copper, and the atomic weight of copper has lately received much attention. Taking the value obtained by Prof. Mallet for copper, which is 63·6 very approximately, the atomic weight of zinc becomes 65·5, oxygen (16) being taken as the standard in each case. This value for zinc is higher than that commonly adopted by 0·5, but there still exists some uncertainty in the matter, and the tendency of recent work is to show that Zn = 65 is lower than the truth. A direct comparison made some years ago by Lieut.-Colonel Reynolds and Prof. Ramsay between zinc and hydrogen gave Zn = 65·48, corresponding nearly to 65·63, when oxygen is taken as 16 instead of 15·96, the figure generally accepted at the time of the investigation; so that it may well be that when the atomic weight of zinc is known with as much accuracy as that of silver, Mr. Murray's result may be found nearer the truth than others at present assumed to be correct.

The Hanover Central Station, designed and equipped by Messrs. Schuckert and Co., is an interesting example of Continental practice in continuous-current work. In the description of this station, which will be found in another column, it will be observed that larger units of plant are employed than is customary in this country. Makers of large engines have not published any exhaustive tests of steam consumption on short runs and variable loads, and there does not at present appear to be any reason for supposing that these engines offer any advantage in economy of steam for such work. If an engine for some 500 or 600 horse-power must be built, the type adopted at Hanover is, no doubt, an excellent one. A breakdown of such engines is, however, so serious a matter that there is a tendency to run them at rather lighter loads than is customary with smaller sizes. In comparing these large dynamos, having 6ft. 6in. commutators, with the continuous-current dynamo commonly used in English stations, it would seem that while, perhaps, there is not a greater total number of brushes in the former case than in the latter, the setting and care of the brushes on these multipolar machines must require a good deal of attention. The drawing of such an armature for repair, and the renewal of the commutator, must be a serious matter.

According to the usual custom, the candidates selected by the "Council of Candidates" of the Royal Society were elected yesterday afternoon. Opposition had been roused within a few days of the election on the ground that one of these candidates was unworthy of this scientific distinction, and another name was suggested by certain Fellows. The wide range of science represented in the Royal Society cannot but give rise now and then to a feeling that one branch is inadequately honoured. It is difficult for a physicist to estimate the value of physiological researches on the functions of an unheard-of organ of some insignificant beetle; and the exact point at which trifling becomes dilettantism, and at which the dilettante is an ornament to the science which he patronises, must always be hard to decide.

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Automatic Signalling.—The Board of Trade has sanctioned the use of the automatic signals on the Liverpool Overhead Railway.

Yarmouth.—The Ratepayers' Association and other ratepayers have drafted petitions against the electric-light scheme adopted by the Corporation, and are placarding the town.

The Salomons Scholarship.—A Salomons Scholarship of £35 has been awarded to each of the following students:—Francis R. Lydall, of King's College; and J. T. Morris, of University College.

Cable Interruptions:—

	Date of interruption.
Paramaribo-Cayenne	April 15.
Santiago de Cuba—Mole St. Nicholas	April 20.
St. Thomé—Loanda	May 30.

The Mercer Fund.—The subscription list for this fund being closed, the Committee are anxious to invest the proceeds as soon as possible, and will therefore be glad to receive the subscriptions promised, which can be sent to the treasurer, Mr. J. Reeves, 3, Bank-buildings, Hastings.

Royal Society.—The following Papers were down for reading yesterday:—Capt. Abney, F.R.S., "On the Colour of Skylight, Sunlight, Cloud-light, and Candle-light"; A. W. Porter, "Note on the Flow in Electric Circuits of Measurable Inductance and Capacity; and in the Dissipation of Energy in such Circuits."

Electrical Bills in Parliament.—The Examiner of Standing Order Proofs in the House of Lords has passed the following Bills:—Electric Lighting Provisional Order (No. 5), Electric Lighting Provisional Order (No. 6), Electric Lighting Provisional Order (No. 1), Electric Lighting Provisional Order (No. 3), Barry Railway.

Wolverhampton Municipal Electrical Engineer.—At a meeting of the Wolverhampton Town Council Lighting Committee on Tuesday, Mr. F. Harman Lewis, electrical engineer to the Corporation of Hull, was appointed to a like position under the Wolverhampton Corporation, at a salary of £300 per annum. There were 36 candidates.

Paris and New York Telegraph Company.—As a result of the recent litigation, says Dalziel, the new Board of Directors of the French Cable Company will be composed as follows:—Marquis de Lauris, Messrs. Chauvassaignes, Decarrere, Lefevre, Pestel, Etard (Administrateur), Bouillaire, de la Beaumelle, Cibiel, Lafargue, and Solomon Halphen.

The Late Prof. Couch Adams.—The Bishop of Truro, on Saturday last, unveiled a new tablet erected in Truro Cathedral to the memory of the late Prof. John Couch Adams, of Cambridge. The tablet was designed by Mr. Pearson, R.A., and executed by Mr. Juleff, sculptor, of Cornwall. The cost of the tablet has been defrayed by public subscription.

Ocean Telegraphy.—A telegram has been received at New York from Chorillos, in Peru, stating that the laying of the duplicate cable of the Central and South American Telegraph Company was completed on Monday. The new cable is 2,524 miles in length, and extends from Salina Cruz, in Mexico, to Chorillos, a port near Lima. It was manufactured by the India Rubber, Gutta Percha and Telegraph Works Company, at Silvertown.

Telegraph Communication with the Azores.—The statement which has appeared in *The Times* and other papers that the negotiations for a submarine cable between Lisbon and the Azores have been finally concluded is somewhat premature, as negotiations are still going on, there being one or two minor points still left unsettled. It is expected, however, that in a few days the business will be completed, and that the cable will be laid by the Telegraph Construction and Maintenance Company, on behalf of the Eastern Telegraph Company, some time in September.

Telegraph Extension to the Mauritius.—The vote for the subsidy in respect of a cable to connect Seychelles and Mauritius with the Eastern and South African Telegraph Company's system at Zanzibar having been approved by the House of Commons, the cable is being manufactured, and will be laid by the Telegraph Construction and Maintenance Company before the end of the year. This important addition to the Eastern Telegraph Company's system has long been contemplated, and will confer a great boon upon the Mauritius, which has much felt its isolation in a telegraphic sense, besides adding an important link to the already very extended network of telegraphs in Eastern seas.

Electrical Trade Section.—A meeting of the Electrical Trade Section will be held at Botolph House, Eastcheap, at 3.45 p.m. to-day. A full attendance is particularly requested. The agenda are as follows:—(1) Minutes; (2) Overhead Wire Regulations (position of matters up to date of meeting); (3) Electric Traction (to consider a motion, notice of which has been given, that a Special Committee of the Section should be appointed with power to raise funds and take such other action as may be necessary to promote the interests of electric traction); (4) Railway Rates (to consider the desirability of representations being made to the Railway Association that a special rate should be granted for the carriage of electrical wire and cable); (5) Other matters.

Lightning.—A fishing boat arrived at Newhaven on Thursday morning of last week in a considerably damaged condition from the effects of lightning. While lying in harbour, the boat was struck by lightning. The first contact seemed to have been at the masthead, and the current, passing down the steel-wire jibhalyards, went completely through the boat's gunwale, leaving an opening about 9in. wide. On the other side of the boat part of the gunwale was torn away for about 10ft. to 12ft. The wire rope immediately above the clip-hooks was entirely consumed. On Monday last, during a thunderstorm at Lewes, a Corporation *employé*, whilst at work with another man at the Corporation Wharf in North-street, was struck by lightning and sustained an injury to his eyes.

The Popp Company.—*L'Industrie Electrique* states that the system of electrical distribution adopted by the Popp Company, now the Compagnie Parisienne de l'Air Comprimé, is about to be completely reorganised, MM. Cuenod, Sautter et Cie. having contracted to lay down a plant similar to that in use at Genoa. At the Rue St. Fargeau central station there are to be three 275-ampere, 1,100-volt Thury dynamos connected in series. These machines will supply current to 21 Thury continuous-current transformers, of which 13 will have an output of 300 amperes, and eight of 600 amperes at 115 volts. These transformers will charge accumulators from which the lamp current will be taken. The Popp system seems unable to disassociate itself from roundabout methods. The new plant is to be in working order by October 1st.

"Telegraph Cable Lodge."—A masonic lodge, under the above title, was consecrated on the 30th ult. at the "Ship and Turtle," Leadenhall-street, E.C., by the Grand Secretary, Mr. E. Letchworth, assisted by Messrs. T. Fenn, J. C. Parkinson, Frank Richardson, Sir George Harris, and the Rev. J. Brownrigge. The Marquis of Tweeddale was installed as first Master, with Sir George Elliot, Bart., and Major Alexander Wood, as Senior and Junior Wardens. The other offices were filled as follows:—Treasurer, Mr. T. A. Bullock; Secretary, Mr. W. T. Ansell; I.P.M., Mr. F. Moll; S.D., Mr. W. Hibberdine; J.D., Mr. F. Weniger; I.G., Dr. Wholey; D.C., Mr. C. B. Barnes; and W.S., Mr. O. Moll. A large company, including Lord Cremorne and many other grand officers, sat down to the banquet which followed.

The City Lighting.—At the last meeting of the Commissioners of Sewers Mr. Morton brought under the notice of the Court the fact that the Press Association premises in New Bridge-street, which had been fitted at great cost, remained unlighted by electricity, and he asked why the private electric lighting in the City had been so long delayed. Mr. Morton concluded by moving that the Company should be communicated with on the subject. This motion, having been seconded, was adopted. It was also resolved, on the motion of Mr. Johnson, to instruct the Streets Committee to prepare a report upon the subject of laying telephone tubes in conjunction with the electric lighting arrangements. On the motion of Mr. Barham, seconded by Mr. Smallman, it was decided to communicate with the Electric Lighting Company on the subject of the space it was utilising in the City for transformer stations.

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Personal.—Mr. Sidney H. Wells, Wh.Sc., Assoc.M.Inst., C.E., Assoc.M.Inst., M.E., of the Yorkshire College, Leeds, has been appointed Principal of the Battersea Polytechnic Institute. Mr. Wells was formerly assistant master on the engineering side of Dulwich College, and, in addition to scientific education, has had the advantage of a practical training in the works of Messrs. Maudsley's, Westminster.—Mr. Cawley, who has been chief editor of *Industries* since our contemporary was started some seven years ago, is about to retire, but not before gaining for *Industries* an established position in the field of technical journalism. At the beginning of this year a change occurred in the proprietary of our contemporary, and this, we understand, led to Mr. Cawley tendering his resignation. After concluding his editorial work he intends carrying on business as consulting engineer, and has taken offices at 29, Great George-street, Westminster, S.W.

Institution of Civil Engineers.—The annual general meeting of this Institution was held on Tuesday last. The gross numbers on the books on March 31 in 1892 and in 1893 were 6,239 and 6,397 respectively. The total receipts for the year 1892-93 amounted to £25,276. 19s. 2d. The general expenditure has been £16,527. 17s. 6d. (including £7,750 for publications and for premiums under Trust, £522. 2s. 10d.); while there has been invested £8,254. 12s. 2d. The summary of investments show that there stand to the credit of the Institution £111,400, with Trust Funds of the par value of £15,606 0s. 10d., together £127,006. 0s. 10d. The ballot for Council resulted in the election of Mr. Alfred Giles, as President; of Sir Robert Rawlinson, Sir B. Baker, Sir Jas. N. Douglass, and Mr. J. W. Barry as Vice-Presidents; and of Dr. W. Anderson, Mr. A. R. Binnie, Sir Douglas Fox, Sir Chas. A. Hartley, Messrs. J. C. Hawkshaw, C. Hawksley, and Alex. B. W. Kennedy, Sir Bradford Leslie, Mr. J. Mansergh, Sir Guilford Molesworth, Mr. W. H. Preece, Sir E. J. Reed, and Messrs. W. Shelford, F. W. Webb, and W. H. White, as other members of Council.

Obituary.—Dr. Franz Stenger, who recently succeeded the late Dr. Lowenherz as Director of the Physikalisch-technische Reichsanstalt at Charlottenburg, died on the 21st ult., at the early age of 34 years. Dr. Stenger was for some time Professor of Electricity at the Technische Hochschule of Dresden.——We have also to record the death, on the 23rd inst., of Samuel Elkins Phillips, F.C.S., in his 80th year. He was associated with the late Dr. Whitehouse in the early days of the first Atlantic Cable project. Later he was appointed superintendent of the Benghazi Station on the line connecting Malta and Alexandria, *vid* Tripoli and Benghazi. On returning to England he was appointed by the Government one of the superintendents who were sent out with the Persian Gulf Cable, and in this capacity was in charge of the Bushire Station.——Mr. A. W. Meston, the inventor of the Meston alternating-current motors, a brief description of which we gave in our TRADE NOTES of May 19th, recently died at his residence, St. Louis. Mr. Meston was a Scotchman by birth. He went to America, when a lad of 14, and studied electrical engineering at the Washington University. His special study was that of adapting small alternating-current motors for use on single-phase circuits.

The American Institute of Electrical Engineers and Visitors to the Chicago Exhibition.—The following letter from the Secretary of the American Institute of Electrical Engineers has been received by the Secretary of the Institution of Electrical Engineers :—

MY DEAR SIR: I take much pleasure in informing you that the World's Fair authorities have placed at our disposal two rooms adjoining the official head-quarters in the Electricity Building at Chicago, which I am expected to occupy as the head-quarters of the Institute during the Exhibition season. The rooms will be fitted up with all essential conveniences, and the Members of the Institution of Electrical Engineers will be welcome there at all times. Letters may be forwarded in the care of the Institute, and I shall be pleased to be of any possible service to our visitors. The house of the American Society of Mechanical Engineers, at 12, West Thirty-first-street, New York City, where our regular head-quarters are established, will also be available to your members while in this city. Arrangements are now being perfected to make it a general bureau of information for visiting engineers, and a special invitation has been extended to friends of the American Institute of Electrical Engineers and the American Institute of Mining Engineers, to consider the house of the Mechanical Engineers their resort for such facilities as it affords. It is conveniently located in respect to the finest hotels and theatres, and with elevated railway and cable tramway facilities to other parts of the city. Trusting we may have the pleasure of meeting many of our European friends during the season,—I beg to remain, yours very truly, RALPH W. POPE.

New American Wiring Rules.—"The uncalled-for mystery surrounding the discussion and promulgation of the fire-underwriters' rules that have been under consideration since last August has," says the *Electrical World*, "finally been dispelled." These new rules, which have now been submitted to the various companies concerned for adoption, are the result of the deliberations of underwriters' experts held in New York last August and December, whose meetings also resulted in the formation of the Underwriters' International Electric Association. Among the features of the new rules are the prohibition, by implication, of wooden cleats and the requirement that all telegraph, telephone and similar conductors shall be provided with some protective device where they enter a building. All safety fuses must be stamped or otherwise marked with the number of amperes they will carry. Another prohibition is that of multiple-series lighting. The smallest wire that can be used outside conduit tubing and fixtures has been reduced from 16 B. and S. to 14 B. and S. The use of staples is absolutely prohibited. Taken as a whole, the rules," says our New York contemporary, "are characterised by sound common sense, and show a due appreciation of the interests of those to whom they are to be applied. Their general adoption now rests with the various insurance companies and associations interested in electrical risks, and it is most sincerely hoped that these bodies will take speedy action toward their adoption, and thus remove a reproach to electrical inspection which has heretofore existed, on account of the number and disparity of independent rules in existence."

Telephone Poles at Broughty Ferry.—What, says the *Dundee Courier*, is to be the upshot of the dispute pending between the Broughty Ferry Police Commissioners and the Telephone Company, is a question that is at present engaging a good deal of attention in the burgh. The time fixed by the Commissioners for the Company to make an acceptable offer to them for wayleave is now rapidly expiring without an agreement being come to, and therefore interest in the question is daily deepening. Naturally subscribers are not viewing with equanimity the prospect of losing the telephone service with which they have been accustomed, and news of a settlement would be welcomed by them. The general public have no such interest in the continuance of the service; the action of the Commissioners in endeavouring to tap the Company meets with approval; and from the offer made by the Company it hardly needs to be pointed out that the Company has admitted the principal of payment to the Board to be right. Inadequate as the offer of the Company is considered by the Commissioners to be, it is, we understand, the utmost that will be given, and that the Company have resolved to adhere to their previously-declared purpose of striking Broughty Ferry off the system rather than yield. Equal firmness on the part of the Commission means, therefore, that after June 14th next telephonic communication between Broughty Ferry and the outside world will be suspended. Then will have arrived, if not before, a period of agitation and trouble that will try the nerves of many in the burgh.—A representative deputation of subscribers attended a meeting of the Broughty Ferry Commissioners on Monday night last. It was explained on behalf of the deputation that they had no wish to do anything to weaken the hands of the Commissioners in their negotiations with the Company, but it was pointed out that great inconvenience would be entailed by the closing of the system in the burgh. The position, from the Commissioners' point of view, was explained to the deputation, and it was also pointed out that though the Commissioners insisted upon the removal of the poles from the streets in the event of the Company refusing to pay for them, there was thereby no compulsion on the Company to resort to the extreme step of closing the whole system in the burgh, as it would still be open for the Company to treat with private parties for situations for the poles the same as has been already done in other cases. The outcome of the Commissioners' deliberations was that they resolved to ask a rent of 10s. per annum for each pole, and three free instruments. There being 54 poles on the streets, the total sum would thus be £27.

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ELECTRICITY AS A MOTIVE POWER.*

BY ALBION T. SNELL.

(*Continued from page 32.*)

§12. Practical Example of Preceding Method of Design.

The application of the principles of dynamo and motor design, described in the preceding sections, is fairly illustrative of the ordinary methods followed in most drawing offices, but the details are varied to suit the fancy or necessities of each engineer.

The design has been treated in a general way so as to include as many cases as possible, and hence appears to be complicated. In practice, however, owing to fixed types of field magnets, definite sizes of armature plates, and data from machines already built, it is very simple. A machine can be designed for a given output at the required speed in a very short time; indeed, nearly all of the calculations will be in simple proportions that can be seen at a glance on a slide rule.

However, to illustrate the use of the equations the following calculations for a 25-unit dynamo and a 25-B.H.P. motor are appended.

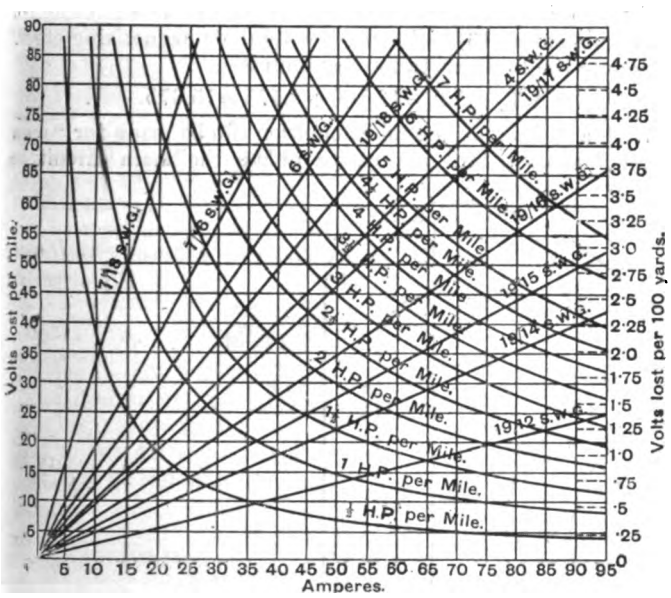

PLATE II.—Curves showing Volts lost per Mile and per 100 Yards with different Currents and usual Sizes of Cable. Calculated from the formula—E = (·0427/area) C. Also H.P. lost per Mile.

It is assumed that the problem is to build a pair of machines to transmit 25 B.H.P. a distance of one mile from the dynamo. Since there is only one motor, the series winding will be most suitable for both machines, this arrangement giving fairly good speed regulation of the motor for variable load if the generator speed be kept constant.

The efficiency of the motor may be safely taken at 90 per cent., and, therefore, the watts absorbed by it at full load will be

$$\frac{25}{\cdot 9} = 28{\cdot}32 \text{ E.H.P.}$$

If the line loss be fixed at 5 E.H.P., the output of the dynamo will be 33·32 E.H.P. = 24,857 watts. On referring to Plate II., which gives the volts and horse-power lost per mile of cable, with different currents and areas, it is seen that a wire of sectional area corresponding with No. 6 S.W.G. will carry 35·75 amperes with a drop of 52 volts and a loss of 2·5 E.H.P. per mile. This is a convenient size wire, as small as it is practically safe to erect for a permanent line and not too costly; it weighs 589lb. per mile, and has a resistance of 1·4694 ohms for the same length. The two miles of line wire will therefore have a resistance of 3 ohms nearly and the fall of potential will be 104 volts, and the watts lost in it 3,730. Dividing the dynamo output by the current (35·75 amperes), the potential difference is seen to be approximately 695 volts. Since the tension is high the armature winding will be of the gramme type, and the double magnetic circuit two-pole field (Fig. 4) will be selected for both machines. The armatures will be made interchangeable in order that one "spare" will cover the two machines; and the field carcases will also be identical save in respect of the number of ampere-turns, and perhaps the area of the magnet cores.

Determination of Armature dimensions.—

From $l\ D^2\ n\ 0\ 01$ . . . . . (1)

$$15 \times 15^2 \times 800 \times 0{\cdot}01 = 28{,}000.$$

Where $l = 15$, $D = 15$, $n = 800$.

This will give a safe margin in output,

Now, $E = e + i_a\ (r_a + r_m)$ . . . . . (5)

and, also $E = 695 + 0{\cdot}06 \times 695 = 736$. . . *From Table A.*

(Take one and a-half times the percentage, since the field resistance must be included.)

$$\mathbf{N}_a = \mathbf{B}_a'' \ 2\ rl\ 0{\cdot}85 \ (7) \ (\textit{see} \text{ Table B}).$$

$l = 15$, let $r = 2{\cdot}5$, and $\mathbf{B}_a'' = 110{,}000$

$$\therefore \mathbf{N}_a = 110{,}000 \times 5 \times 15 \times 0{\cdot}85 = 7{\cdot}0 \times 10^6.$$

Put this trial value of $\mathbf{N}_a$ in (8)

$$C_a = \frac{E60}{\mathbf{N}_a n 10^{-8}} = \frac{736 \times 60}{7{\cdot}0 \times 10^6 \times 800 \times 10^{-8}} = 780.$$

The circumference of armature = $\pi d = 47''$, deduct a space of $2''$ for the driving horns, leaving $45''$ for the winding. No. 11 S.W.G. will carry 17·875 amperes at a density of 1,800 amperes per square inch: it is $0{\cdot}116''$ in diameter when bare, and with 16 mils. of insulation = $0{\cdot}132''$. Therefore, with No. 11 wire the turns per layer would be $\frac{45}{0{\cdot}132} = 340$. Two layers would = 680 turns, *i.e.*, say 68 coils of 10 turns each. The resistance when cold will be about 0·37, and hot about 0·4 ohms.

Ampere-turns per coil = $10 \times 17{\cdot}875 = 179$ say

Permissible circumflux = D 1000 = 15,000 . . . . . (9)

Arranged circumflex $= \frac{i_a C_a}{2} = \frac{35{\cdot}75 \times 680}{2} = 12{,}200.$

Two layers of this wire give fewer turns than the value of C_a determined from (8), and *three* layers would give too many, besides increasing the air gap unduly, and raising the circumflux above the safe limits given by (9). This is a common case in practice; the remedy is to raise the speed, or to increase the armature induction; or to do both,

making $n = 800 \frac{780}{680} = 920$, say;

or, making $\mathbf{N}_a = 7{\cdot}0 \times 10^6 \frac{780}{680} = 8{\cdot}00 \times 10^6$;

or, by varying both n and $\mathbf{N}_a$.

To illustrate these points the latter method is chosen.

Since $\mathbf{B}_a''$ is already 110,000, in order to increase $\mathbf{N}_a$ it is necessary to make the cross section of the armature larger, alter the radial depth of core r from $2{\cdot}5''$ to, say, $2{\cdot}75''$. Therefore $2\ l\ r$ will = 82·5 sq. in., and the effective armature section will be $82{\cdot}5 \times 0{\cdot}85 = 70$ sq. in.

The new value of $\mathbf{N}_a$ is therefore

$$7{\cdot}0 \times 10^6 \times \frac{2{\cdot}75}{2{\cdot}5} = 7{\cdot}7 \times 10^6.$$

The speed must be raised to give the required conditions. Substitute these new values in (8), and solve for n

$$n = \frac{E\ 60}{C_a\ \mathbf{N}_a\ 10^{-8}} = \frac{736 \times 60}{680 \times 7{\cdot}7 \times 10^{-2}} = 835.$$

The bore of the poles must next be determined. Allowing for two layers of No. 11 S.W.G., suitable insulation, bands, and clearance of, say, 0·0937 (3/32″) of an inch all round the required bore is 15·75, and $\therefore \delta = 0{\cdot}375$. And let the angular width of the pole pieces be 120° at the edges, and 125° in the centre; *i.e.*, let the "horns" be curved in a direction parallel to

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the winding (*see* Fig. 13). This tends to destroy the abruptness of the magnetic flux, and to distribute it more gradually on the leading horns. The average width of the pole pieces, w, is 122·5°, or, say, 17″.

The length of the poles should be a little less than that of the armature core, say, in this case, 14·5. Therefore the area of each cavity is $17 \times 14{\cdot}5 = 247$ sq. in., and B''_g, the density in the gaps is found by dividing N_a by 247;

$$\text{or,} \quad \frac{7{\cdot}7 \times 10^6}{247} = 31{,}000.$$

This is a convenient density.

Next, to determine the field induction:

$$N_f = v\,N_a = 1{\cdot}42 \times 7{\cdot}7 \times 10^6 \quad . \quad . \quad . \quad (v = 1{\cdot}42)$$
$$= 10{\cdot}95 \times 10^6,$$

and half of this flux, $5{\cdot}475 \times 10^6$, must be supplied by each limb of the magnet.

Let the cores be wrought iron, and $B_f'' = 85{,}000$ say, and the area of each core $= \frac{5{\cdot}475 \times 10^6}{8{\cdot}5 \times 10^4} = 65$ sq. in. nearly.

Now the length of the pole pieces has been fixed at 14·5″, let the magnet cores be the same, then the width of each core is

$$\frac{65}{14{\cdot}5} = 4{\cdot}5''.$$

The dimensions of the machine are now sufficiently developed to enable a drawing to be made showing a cross section of the field and armature cores; let this be to, say, an inch and a-half scale, as in Fig. 13. The length of the magnetic paths can be estimated, and the field winding calculations made.

$m_f = 23''$; $m_{f1} = 16''$; $m_a = 7''$; $2\,l\,r = A_a = 70$; $A_f = 14{\cdot}5 \times 4{\cdot}5 = 65{\cdot}0$; $A_{f1} = 93$; $B_a'' = 110{,}000$; $B_f'' = 85{,}000$; $B_{f1}'' = 50{,}000$; and $B_g'' = 31{,}000$.

The path of the induction in the armature can only be averaged, since the density is not constant (*see* Fig. 14), which has been drawn specially to show the probable distribution of the lines of force. It is noticeable that the maximum induction only takes place in the areas bounded by the lines $a\,a_1$ and $b\,b_1$. Averaging the path to the density chosen, $B_a'' = 110{,}000$, it is seen that the mean distance between the pole tips is a fair approximation to the value of m_a. It is also interesting to mark how the direction of the lines is altered after leaving iron and entering air. This is to be expected from the very different permeabilities of the two media, a subject which is engaging the attention of experts.

The excitation per limb for full load is from (12)—

A.-T.'s for armature	$= m_a f(B''_a) =$	$7 \times$	$280 = 1{,}960$
,, cores	$= m_f f(B''_f) =$	$23 \times$	$77 = 1{,}771$
,, pole pieces	$= m_{f_1} f(B''_{f_1}) =$	$16 \times$	$130 = 2{,}080$
,, gap	$= 2\,\delta f(B''_g) = 0{\cdot}75 \times 9{,}750 =$		$7{,}300$
			$13{,}111$

The various "functions" for the determined values of the inductions are read direct from the proper curves in Plate I. Let the value of the ampere-turns be taken at 13,100.

To find the demagnetising turns: Let the maximum angular lead θ be 27°, *i.e.*, nearly to the tip of the leading "horn." Then, by (13), the compensating turns are

$$C.T._a = C_a \frac{\theta}{180}\, i_a\, v,$$
$$= 680\, \frac{27}{180} 35{\cdot}75 \times 1{\cdot}42,$$
$$= 5{,}150 \text{ nearly.}$$

(For value of "v" see Table D.)

And 2,575 ampere-turns must be added to the excitation of each limb, since (13) estimates the total demagnetising effect. Therefore the total excitation per limb is

$$A.T._a + C.T._a = 13{,}100 + 2{,}575 = 15{,}675.$$

With a series machine no calculation can be made for "open circuit," since it will not excite unless the main circuit be closed. If the dynamo be compound-wound, this calculation is necessary in order to determine the shunt winding; but for a simple shunt machine it is usually sufficient to determine the excitation at full load only.

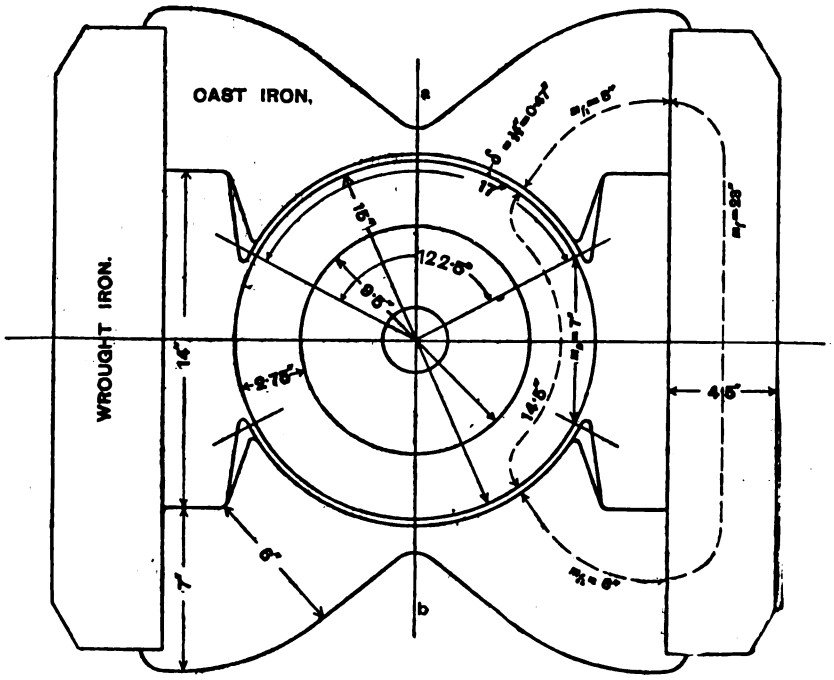

FIG. 13.—Cross Section of Dynamo, showing Method of Designing.

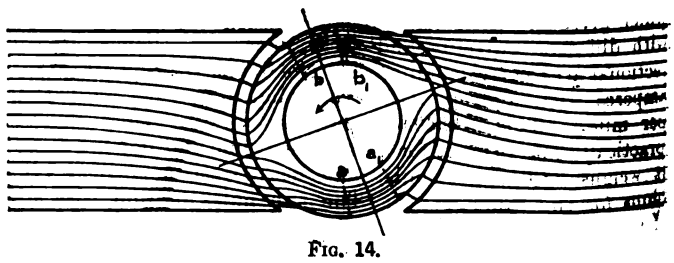

FIG. 14.

It now remains to find the gauge of wire for the field windings. This can be done in several ways, each depending on the result aimed at.

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In a series machine* the current is fixed, and thus the gauge of wire is given by the heating effect, *see* § 9 (*a*); and the number of turns must be selected to give the proper excitation. In the design under consideration the convolutions required

$$= \frac{15675}{37{\cdot}75} = 440 \text{ per limb,}$$

and No. 5 B.W.G. will carry 38 amperes at a density of 1,000 per square inch of section; and this will give an ample margin. The resistance hot is

$$\frac{440 \times l_1 \times 0{\cdot}00064}{36} = \frac{440 \times 34 \times 0{\cdot}00064}{36} = 0{\cdot}258$$

where l_1 = length of a mean turn in inches, and 0·00064 = resistance of one yard of the wire.

The winding space is 14in. long, allowing 0·75in. for the two flanges of the "shape," and for insulation, there is left a net length of 13·25in. Now 4·25 turns of No. 5 B.W.G. (with 16 mils. insulation) will occupy 1in., and so the convolutions per layer will be 56. The turns per coil are 440; hence, 8 layers are required. The depth of the winding is approximately 2in.

The resistance of the two coils is about 0·516 ohms, and the total resistance of the dynamo 0·916 ohms. The pressure lost over this is—

$$35{\cdot}75 \times 0{\cdot}916 = 33 \text{ volts nearly.}$$

Now, in fixing the value of E, a fall of 6 per cent. or 41 volts, was allowed. The winding is thus within the required conditions. If desirable, the value for the total E.M.F. can now be readjusted and the calculations amended accordingly. Practically, however, it is sufficient to decrease the speed in the ratio of

$$\frac{695+33}{695+40} = \frac{728}{735} = 0{\cdot}99,$$

and speed = 835 × 0·99 = 830 revolutions per minute.

The design of the dynamo is now complete. That of the motor is substantially the same; but special care must be given to the driving horns and general details of the armature. The speed of the motor is proportional to the back E.M.F., *i.e.*, to

$$E_1 - i_a (r_a + r_m)$$

and the torque is:

$$\frac{\text{B.H.P.} \times 33{,}000}{2\pi n}, \text{ from (18),}$$

or

$$\frac{C_a i_a N_a}{852{\cdot}3 \times 10^6} \text{ from (16).}$$

Now, $E_1 = E - 104 = 632$ volts at motor terminals.

$i_a = 35{\cdot}75.$

$r_a = 0{\cdot}4.$

and let $r_m = 0.25$ (trial value with six layers on field cores, and 660 turns in all).

$C_a = 680.$

And n and N_a are the two unknown variables. If there be any particular speed, then n is also fixed. Let 720 be the required number of revolutions per minute, then $n = 720$, and the torque is given by (18)

$$\frac{25 \times 33{,}000}{2\pi\, 720} = 183 \text{ lb. ft.}$$

The peripheral pull on the armature at full working load is given by (19), and

$$= \frac{\text{B.H.P. } 33{,}000}{2\pi n} \cdot \frac{1}{g} = 294 \text{ pounds.}$$

(g = radius of armature in feet.)

The maximum stress at starting may easily be twice as great, or even more, so it is necessary to allow for a pull of, say, from 800 to 1000 pounds. Equating to (16), the value of the torque found from (18), and taking out N_a, the required value of the armature induction is found, thus—

$$N_a = \frac{183 \times 852{\cdot}3 \times 10^6}{680 \times 35{\cdot}75}$$

$$= 6{\cdot}45 \times 10^6,$$

and,

$$B_a'' = \frac{6{\cdot}45 \times 10^6}{82{\cdot}5} = 78{,}500,$$

$$B_g'' = \frac{6{\cdot}45 \times 10^6}{247} = 26{,}000,$$

$$N_f = 1{\cdot}4\ N_a = 9{\cdot}05 \times 10^6$$

$$B_f'' = \frac{4{\cdot}525 \times 10^6}{65} = 82{,}500,$$

$$B_{f_1}'' = \frac{4{\cdot}525 \times 10^6}{110} = 41{,}250.$$

The excitation is by (12):—

A.-T.'s for armature	$= m_a f(B_a'') =$	$7 \times 24{\cdot}5$	$= 172$
,, cores	$= m_f f(B_f'') =$	$23 \times 66{\cdot}5$	$= 1{,}530$
,, pole pieces	$= m_{f_1} f(B_{f_1}'') =$	16×63	$= 1{,}030$
,, gap	$= 2\delta f(B_g'') =$	$0{\cdot}75 \times 8150$	$= 6{,}120$
			8,852

The demagnetising turns* are practically the same as with the dynamo, and, therefore, the full excitation per limb is

$$\text{A.-T.'s} + \text{C.-T.'s} = 8{,}852 + 2{,}575 = 11{,}427.$$

Dividing this by the current, the required number of turns per coil is 320, or six layers as was assumed in the approximation.

This finishes the calculation for the motor. The figures have been estimated by means of a slide rule, and so are not always quite exact; but they illustrate the use of the equations, and show the general method of designing dynamos and motors. It is interesting to notice that the motor is rather large for the output, and that the inductions in the field cores and gap are consequently much less than those required in the dynamo. This can be obviated to some extent in practice, by reducing the section of the motor cores, making them, say 4in., instead of 4·5in., in depth. Such alterations will readily suggest themselves.

(*To be continued.*)

* If the field coils were in shunt, then the potential difference would be fixed, and the current and turns be variable, the efficiency increasing with the number of turns for a given value of the excitation. Now there is one gauge of wire, and one only, which will give a particular excitation, for the given section of core, at a fixed potential difference. This wire being used, the number of convolutions affects the efficiency and not the value of the excitation. Therefore, it is necessary to find the proper area of cross-section of wire, and usually as it is not a stock size the *next size larger* is chosen. This increases the number of ampere-turns; but an external resistance is easily put in series with the coils, and hence the potential difference can be adjusted for any required excitation. The method followed is to first find the length of a mean turn of the coil, say it $= l_1$ inches; then, the resistance of a mean turn

$$= \frac{e_1}{\text{A. Ts}},$$

where e_1 = the potential difference available; and the gauge of wire can be found by reference to a table of wire resistances.

* Probably the lead at full load will be from 5 deg. to 10 deg. less than that required with the dynamo. If this be so, the compensating turns will be correspondingly less.

EFFECTS PRODUCED BY USING AN INDUCTIONLESS SHUNT WITH A CHOKING COIL.

BY HUGH ERAT HARRISON, B.SC.

Some measurements were being made on the London Electric Supply Corporation's circuit by Mr. G. W. Partridge, for the purpose of which conductors were connected up, as shown in Fig. 1. The points X and Z were connected to the mains, so that the E.M.F. between them was constant, and may be taken as 100 volts. S is the coefficient of self-induction of the choking coil; the other symbols, denoting the current, resistance, and E.M.F. between the various points in the circuit, are shown in the diagram. Before the shunt was brought into use, that is, when $r_2 = \infty$, the E.M.F. between Y and Z was 96; but when the shunt was thrown in to lessen the effect of the choking coil, and slightly raise this E.M.F., it was found the value of e_2, contrary to intention, fell, and on

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diminishing r_2, continued to fall to below 90, after which, on further reducing r_2, e_2 rose continuously, until, when $r_2 = 0$, and the choking coil was completely short-circuited, it became equal to E.

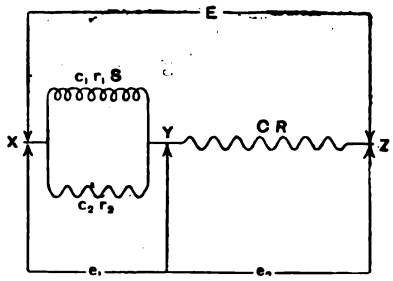

FIG. 1.

That a non-inductive placed in parallel with an inductive resistance may be made to reduce the voltage in an alternating circuit more than the inductive resistance alone, is shown by the more or less complicated equations for finding the currents in the branches of a mixed circuit, but graphical solutions of such problems are more easily followed by those unfamiliar with differential equations.

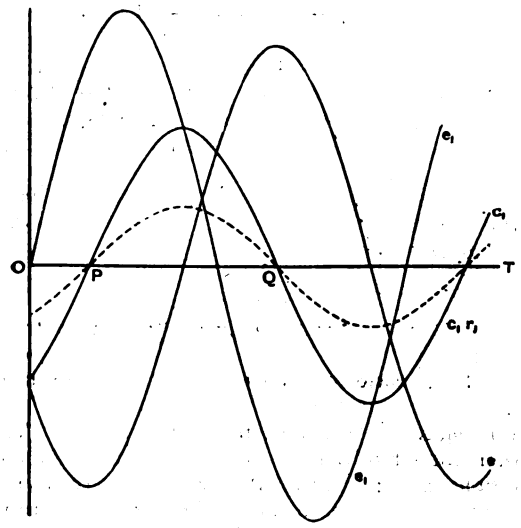

FIG. 2.

Lapse of time being measured along the horizontal line O T (Fig. 2), and the simultaneous values of other quantities in the vertical direction, let the curve e_1 represent the alternating E.M.F. at the ends of the choking coil; the dotted curve c_1 the current in this coil lagging behind e_1, and the curve ϵ the E.M.F. set up within the coil, due to self induction, lagging a quarter-phase behind c_1. If the ordinates of c_1 are multiplied by r_1, the resistance of the coil, a fourth curve is obtained showing the actual E.M.F. that drives the current through the coil, which is the sum of the E.M.F. e_1 applied to the ends of the coil and the E.M.F. ϵ set up within itself.*

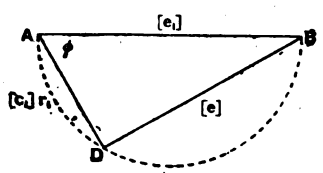

FIG. 3.

Let n = number of ∿ per second, $p = 2\pi n$, and let a symbol enclosed in square brackets, *e.g.* [E], denote the maximum value of the quantity in question.

The distance between the successive points where a simple sine curve ($y = \sin x$) cuts the horizontal axis is π, its greatest slope, which is at these points, is 1, and its maximum height also 1. The distance between the points P and Q on the curve c_1 is $1/2\,n$, its slope at P is therefore increased, above that of the simple sine curve, in the ratio $\pi : 1/2\,n$ or $2\pi n$ fold, but its height is $[c_1]$, hence the slope at P is $2\pi n\,[c_1] = p\,[c_1]$, and the maximum E.M.F. of self-induction $[\epsilon] = p\,[c_1]\,S$.

The resultant E.M.F. driving the current through the choking coil is, as already stated, composed of two E.M.F.'s, ϵ lagging a quarter-phase behind it and e_1 ahead of it in phase.

Lay off A B (Fig. 3), equal to $[e_1]$, describe on it a semicircle, and from B suppose B D drawn equal to $[\epsilon]$, then A D gives $[c_1]\,r_1$,

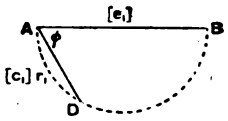

FIG. 4.

making, as it does, a right angle with B D; this shows the lag or difference of phase ϕ between e_1 and $c_1\,r_1$, or e_1 and c_1, that is, the difference of phase between the E.M.F. applied to the ends of the coil and the current which flows in it. Hence

$$\tan\phi = [\epsilon]/[c_1]\,r_1 = p\,S/r_1 \quad \because [\epsilon] = p\,[c_1]\,S$$
$$\phi = \tan^{-1} p\,S/r_1.$$

The lag of c_1 behind e_1 can therefore be easily calculated and, being independent of the current, remains the same, no matter how the currents in the branches are varied, a variation which does not affect p, S, or r_1.

It may be pointed out that Fig. 3 will also give the impedance, I, or apparent resistance of the coil:—

$$I = \frac{[e_1]}{[c_1]} = \frac{[e_1]r_1}{[c_1]r_1} = \frac{r_1}{\cos\phi} = r_1\sqrt{1+\tan^2\phi} = \sqrt{r_1^2 + p^2 S^2},$$

Being now able to find the relations between e_1 and c_1, a simple series of constructions can be drawn to give the relations between all the quantities involved in the circuit. The

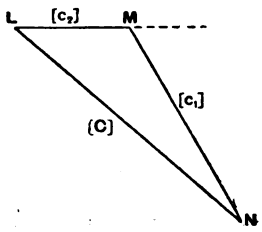

FIG. 5.

currents in the conductors which are inductionless are always in phase with the E.M.F.'s between their ends, and the simple relations $e_1 = c_2 r_2$, $e_2 = C R$, always hold for these instantaneous as for unvarying currents.

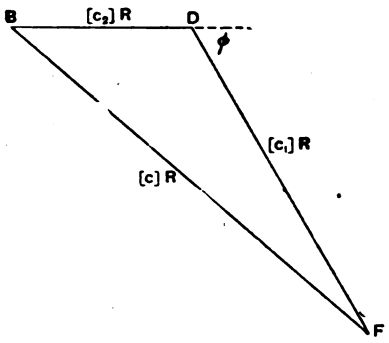

FIG. 6.

If E.M.F. or current be measured by ordinary instruments, the maximum instantaneous values will be $\sqrt{2}$ times those indicated.

In the following diagrams the same letters are used for corresponding points.

First calculate ϕ, then for any value of $[e_1]$ draw A B = $[e_1]$ (Fig. 4), and thus, as explained by Fig. 3, find $[c_1]\,r_1$.

The current C is at any instant equal to the sum of the simultaneous currents c_1 and c_2, though, as these latter are not

* *See* Paper by same Author in *The Electrician*, Vol. XXVIII., p. 223.

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in the same phase, C is not equal to the algebraic sum of these currents as measured on ammeters, nor is $[C]$ equal to $[c_1]+[c_2]$, but the difference of phase between c_1 and c_2 is known to be ϕ; $[C]$ can therefore be drawn as follows. $[c_2]=[e_1]/r_2$; set off $LM=[c_2]$ (Fig. 5); $[c_1]$ is known, since $[c_1]r_1$ has been found by Fig. 4; draw $MN=[c_1]$ making the angle ϕ with L M produced, then $LN=[C]$ in both magnitude and phase. The quantity really wanted, however, is $[e_2]=[C]R$,

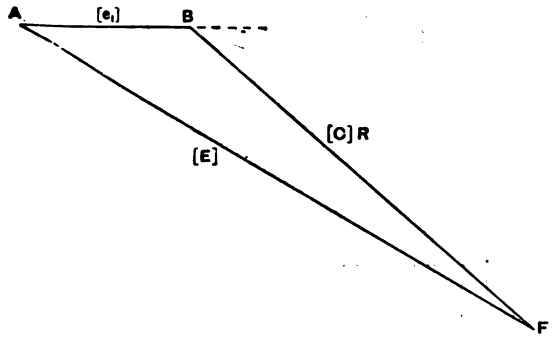

FIG. 7.

which could have been got at once by setting off $BD=[c_2]R$ (Fig. 6), $DF=[c_1]R$, making the angle ϕ with B D produced, when $BF=[C]R=[e_2]$.

Just as C is equal to the sum of the simultaneous values of c_1 and c_2, so is E equal to the sum of the simultaneous values of e_1 and e_2, though not in phase with either.

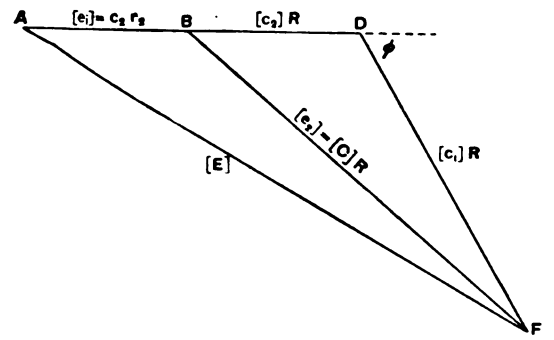

FIG. 8.

To draw $[E]$ (Fig. 7) set off $AB=[e_1]$, $BF=[C]R$, so that the angle B F makes with A B produced is equal to the angle D B F (Fig. 6), then A F gives $[E]$ in magnitude and phase.

The constructions in Figs. 4, 5, 6, and 7 have been shown separately in order that each step might be easily followed, but by piecing together Figs. 6 and 7, Fig. 8 is obtained, showing at a glance the relative values of $[e_1]$, $[e_2]$, $[E]$; the currents in

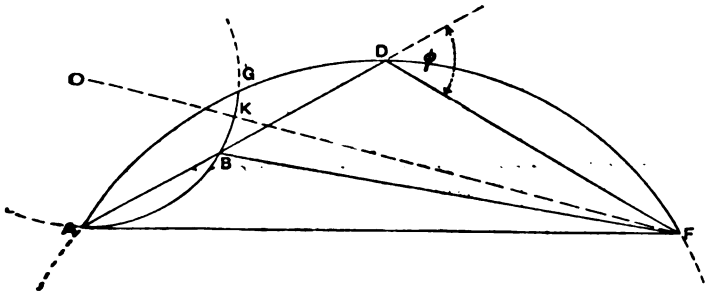

FIG. 9.

the various branches $[c_1]$, $[c_2]$, $[C]$ and their phases, the current in each case being found by dividing the lengths of D F, B D, and B F by the value of R.

In the experiment described at the commencement of the Paper, E, the E.M.F. between the mains, was kept constant, hence A F is constant. S, r_1 and p were constant, hence ϕ is constant, as was also R, but r_2 was changed from infinity down to zero. Since A F and ϕ are constant, D always lies on the arc of a circle passing through A and F. This arc is drawn in Fig. 9. It is not, however, so clear how the all-important point B moves.

From Fig. 4 $[e_1]=k\,[c_1]\,r_1$ where k is a constant.

But $\dfrac{AB}{DF}=\dfrac{[e_1]}{[c_1]R}=k\dfrac{[c_1]r_1}{[c_1]R}=k\dfrac{r_1}{R}$, a constant quantity.

The sum of the angles B A F and D F A is constant, so that when D F turns A B turns through an equal angle; since the ratio between them is constant and D traces out the arc of a circle, the locus of B is also the arc of a circle situated with respect to A B as the arc D F is to the chord D F. The construction of this circle is a matter of elementary geometry. Its centre is at O; it cuts the larger circle at A and G, the limits of the path described by B.

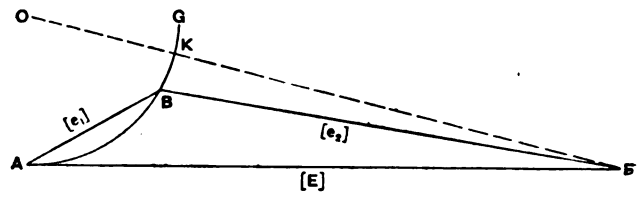

FIG. 10.

When B is at G, $BD=0$; there is no passage through the shunt, and the choking coil alone is in series with the resistance R. When B is at A, $AB=0$, that is, $[e_1]=0$, the choking coil is short-circuited, and the resistance, R, alone is across the mains.

Fig 10 is a reproduction of Fig. 9, omitting all the lines not required for the purpose in view, and, therefore, showing more clearly what happens when the shunt is brought into circuit and its resistance gradually diminished, until the choking coil is entirely cut out.

The E.M.F. between X and Y (Fig. 1) has its highest value when the choking coil is unshunted or $r_2=\infty$. As the point B (Fig. 10) moves towards A, the E.M.F. between Y and Z, Fig. 1, falls until B (Fig. 10) gets to the point K which lies on the line joining F to the centre of the arc G K B A, from thence onwards e_2 increases until the choking coil being short-circuited $[e_1]=0$ and $e_2=E$.

Briefly, the function of the choking coil is to protect or screen the resistance R from the full E.M.F. in the mains. This it does by producing at its ends a certain E.M.F. e_1, out of phase, however, with the main E.M.F. As current is shunted past the coil the value of e_1 falls, and its protecting power is correspondingly *lessened*, but while falling it gets more into phase with E in consequence of which its protecting power is *increased*. From G to K, Fig. 10, the increase of effect due to A B getting more and more into line with A F is greater than the loss of effect due to A B or e_1 getting smaller, so that the E.M.F. B F between the ends of the resistance R diminishes, but as r_2 is further lowered, that is when B has passed K, the reverse takes place, the increase of effect due to A B getting more and more into line with A F is less than the loss of effect due to e_1 getting smaller; B F thenceforward increases continually, until ultimately B F = A F, and the choking coil is completely short-circuited.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, June 2nd.

LONDON CHAMBER OF COMMERCE.

3 45 p.m. Meeting of the Electrical Trade Section

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Study of Fluid Motion by means of Coloured Bands," by Prof. Osborne Reynolds F.R.S.

MONDAY, June 5th.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

WEDNESDAY, June 7th.

ROYAL SOCIETY.

9 p.m. Annual Conversazione.

FRIDAY, June 9th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1) "A New Photometer," by A. P. Trotter; (2) "Notes on Photometry," by Prof. S. P. Thompson, F.R.S.; (3) "The Magnetic Field Near a Wire," by Prof. M. Minchin, M.A.

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PHYSICS AND METAPHYSICS.

The greater part of the last two meetings of the Physical Society has been devoted to the reading and discussion of a Paper by Dr. OLIVER LODGE entitled "The Foundations of Dynamics." In this Paper, which will no doubt shortly be published elsewhere, the author deals with "The Nature of Axioms," "The First and Third Laws of Motion," "The Conservation of Energy and Universal Contact-Action," and other subjects, amongst which are the "Nature of Potential Energy," and the ever-to-be-discussed "Second Law of Thermodynamics." Appendices to this Paper deal with "The Objectivity of Energy and its Transmission." From one point of view it may be considered somewhat late in the day—or rather in the century—to deal with the foundations of so highly developed a structure as that of Dynamical or Physical Science. We may investigate the foundations, examine any weak places, and perhaps lay a footing for some new extensions, but a project for underpinning the whole fabric and for pulling out the old work and replacing it by new materials laid in a more modern fashion will find but few sympathisers. These foundations consist of so-called "axioms," "rational notions," "self-evident truths," and the like. It is possible that from time to time a little modification may be necessary, for in the history of science there is more than one striking example of collapse and of subsequent reconstruction, and though no widespread disaster can be conceived which could put Physical Science to confusion, it is well, perhaps, that a few cool-headed explorers should now and then leave their test-tubing and their spot-watching, and, descending below the pleasant

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world of experimental science, grope and survey the foundations which lie among the murky regions of metaphysics. Systems of astronomy, of botany, of chemistry, and of geology, laboriously built, have been in some cases quickly razed, and in others have gradually fallen into ruin. In most of these there was but a halfpennyworth of experimental observation to an intolerable deal of theorising. The observations, such as they were, were for the most part sound, and the result of much patient work. Many are still useful, and even the misconstructed ones are instructive. The theorising was generally rash, and the generalisations which once seemed to be of fundamental importance hardly possess even interest to-day.

But here we must leave the metaphor. If these foundations consist of axioms, what is an axiom? The definition, "a proposition whose truth is so evident that no reasoning or demonstration can make it plainer," is a feeble one. It might be pleaded by a lazy student that the fourth proposition of EUCLID's first book, together with one or two others, are axioms, and if the evidence of a truth has anything in common with the intellectual effort of appreciating it, some of these propositions are more worthy of being called axioms than several of the so-called axioms of geometry or of dynamics. A better definition of an axiom, and one at least which does not seem to shirk the *onus probandi*, is "a concept based on experience." This does not make a vain attempt to treat an axiom as a ridiculously simple affair; on the contrary, it can only be rationally discussed by one who has had experience and whose mental powers are capable of apprehending a purely abstract notion. In this sense, then, the metaphor of foundations fails, for an axiom is the result, and not the starting point, of experience and thought. If not foundations, then, what are these knotty ideas and debatable laws and doctrines? They appear to be generalisations by which knowledge may by systematisation become science. So far from being postulates, they are the final inferences of reasoning. Viewed in this light, axioms become in the highest degree descriptive, and are proportionately valuable. Regarded as mere premises or initial ideas, axiomatic laws such as NEWTON's laws of motion, or definitions such as those of force, mass, or energy are likely to lead, if too closely discussed, into tangled controversy and intricate reasoning. Verbal definitions, said a speaker at the last meeting of the Physical Society, can only lead to verbal conclusions.

Verbal definitions are of this use, that having settled upon them, each may know what the other is talking about. An idea of "uniform motion in a right line" may be acquired by any school-boy, but it appears that if he is tempted to improve on this idea he will not only suddenly find himself out of his depth, but will to his great surprise discover that the profoundest thinkers well-nigh despair of defining exactly what is meant by these words. The fact, however remains, that except for the purpose of quibbling and prying into the limitations not of our knowledge, but of our vocabulary, the expression "uniform motion in a right line" conveys all that it need convey to him to whom they may be addressed. True, one man may be unable to define to the satisfaction of himself or of another what he means by "a right line," and somebody else who has trifled too much with philosophy may have so addled his brain that he cannot satisfy himself with a definition of "uniform motion." Verbal definitions truly lead to verbal conclusions, and we may add that verbal quibblings lead to verbal confusion. Our vocabulary is large enough to furnish names for the fundamental ideas of most sciences, and new terms can be coined from Greek if need be. We restrict the word "energy" to a definite meaning differing altogether from that in which ARISTOTLE used the Greek equivalent, and we have divested "force" from its many vague uses, and have restricted it to one well-defined idea. If anything is to be gained in the study of Physics by going behind the scenes into Metaphysics, let those who are competent to do so plainly tell us.

Alleys, some of them *culs de sac*, lead off from every path of science, but only the strong man can force his way through them and come out again on the highway having made real progress. How much time has been fruitlessly spent on abstract considerations of space? Is the Universe infinite? This was the question which Sir ROBERT BALL asked and sought to answer in the *Fortnightly Review* for last month. The dilemma of space, that it must either be infinite or there must be a boundary behind which there is an infinite unknown, Sir ROBERT BALL argued, no longer existed. The notion that one could travel on and on in a straight line for ever, and the idea that, if one went far enough, one would come against the "brick wall" of space, are equally unnecessary, and are alike based upon a fallacy. Who says that two parallel straight lines do not meet till produced to infinity? Who maintains that the three angles of a plane triangle are together equal to two right angles? Ah, but he cannot prove it, neither is it axiomatic. If we stand on the sea shore, we may draw two parallel lines in the sand, and say to ourselves that if they are produced they will either reach the edge of the world or else the world must be infinitely extensive; forgetting that Columbus could have told us that by following those parallel lines we should get back to the starting point in a finite time. So, standing upon the sea of space, and looking along what seems to be a straight line across it, we may really be looking along a gigantic curve, which, if followed, would bring us back to the origin in a finite distance. Space may be a closed curvation, a three-dimensional spherical "surface," as it were, possessing neither boundaries nor infinite extent.

Logic enables us to think without confusion, and in moderate doses is of great use to the physicist. To meddle further with abstract reasoning is likely to do him more harm than good. It is the fashion for students of the natural sciences, even while they are talking metaphysics, to say that metaphysics is rubbish; and it is the fashion for metaphysicians to say that there is no real physics but metaphysics. The diseased state of mind into which intelligent men may fall if they allow themselves to obscure plain ideas with philosophical considerations is well exemplified by the problem which DR. LODGE gives about the horse and cart. He says that he "constantly finds examination candidates, and even engineers, when catechised about a horse pulling a cart, though they may, some of them, politely admit that approximately the pull of the horse and the pull of the cart are equal (constituting the stress in the trace whose inertia we may agree to neglect), yet nevertheless assert that in reality the pull of the horse must be the least little bit bigger than the back pull of the trace, else the thing could not start." Unhappy "candidates and even engineers"! Unless such a difficulty were suggested externally, no natural mind could conjure it up. Would not the paradox, such as it is, be greatly increased by assuming the harness to be an epidermal extension of the horse, or by tying a loop in its tail dispense with the massless trace? The old Greek philosophers who had nothing better to do rejoiced in such puzzles. There was one about a fish; we do not remember the exact proposition. A fish was in a bowl of water. The fish could not move unless the water gave place before it. But the water could not move until the fish displaced it; how, then, could the fish ever move? The

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problems of ACHILLES and the tortoise, or the modern version, of the minute-hand and the hour-hand of a watch, are really of more interest than these horse, cart, and fish dilemmas, for the summation of fractions, and the true presentation of the problem are instructive.

The intention of Dr. LODGE's Paper and discussion appears to be to examine the fundamental ideas, and to see whether they are resolvable into components, and to discuss whether one be more fundamental than another. The resolution of energy into two factors, as pointed out by Prof. S. P. THOMPSON in the adjourned discussion, is, indeed, a point of no little importance when the objectivity or identity of energy is under consideration, but to argue whether mass or force is the more fundamental idea does not seem to be of much utility. The more familiar, or apparently simple, idea claims the place, and as these attributes are matters of opinion, no definite conclusion is possible. Dr. OLIVER LODGE, we understand, prefers to take "force" as fundamental and "mass" only as an inference, as a useful secondary idea. He admits that "heat is a convenient term; there are reasons for using it." In these and similar preferences we cannot but think that he is in a small minority. Let us by all means clear our ideas about mass and force and time, but to tear to pieces such useful conceptions by desperate attempts at new and perfect definitions is like the inquisitive destruction of toys by a child. He is generally sorry in the end for the mess he has made.

REVIEWS.

Alternating Currents. By F. BEDELL, Ph.D., and A. C. CREHORE, Ph.D. (New York: W. J. Johnston and Co.)

According to the authors of this book, the recent advances in the applications of alternate currents have been so numerous and important that "there are now many interested in this field of work who desire to become conversant with the underlying principles of the subject, in order that they may become better equipped to undertake the vast engineering problems which are constantly arising." The hurried way in which the subject has advanced has caused the theory to be "developed this way and that, and added to here and there, so that it is necessary for one to stop and consider the basis from which certain conclusions are reached, and the logical sequence by which the results are attained." The authors, however, have made a mistake in attempting to supply this want by writing a book which is from first to last a purely mathematical work. Reference to experiment there is none, unless numerical examples in illustration of the formulæ can be accounted as such. It has been more than once pointed out that, unless a liberal interpretation is given to the symbols used in alternate-current mathematics, the formulæ arrived at do not represent experimental results. No indication is given in the book of methods, practical or otherwise, of determining those two or three quantities with which the whole book is concerned. No reference, indeed, is made to any kind of alternate-current measuring apparatus. The book is far more suitable for mathematicians who have heard about the existence of alternating currents, and desire to have them explained in a mathematical fashion, than it is for electricians wishing to gain precise ideas about the principles underlying their work.

The book consists of two parts, devoted respectively to the analytical and graphical methods of treating the subject. The first part is well illustrated by a number of curves drawn to represent special cases, the numerical details of which are given. These curves show very clearly the nature of the electrical actions going on. But the analytical portion betrays too great a tendency to desert electrical matters and wander into the regions of pure mathematics. Thus, when discussing on p. 42, the equation

$$e = \mathrm{R}\,i + \mathrm{L}\frac{d\,i}{d\,t},$$

the authors think it advisable to consider the condition of integrability of the general type of a differential equation of the first order, involving three variables, viz.,

$$\mathrm{P}\,d\,x + \mathrm{Q}\,d\,y + \mathrm{S}\,d\,z = 0;$$

and having, by means of a reference to Johnson's Differential Equations, obtained this condition in the form

$$\mathrm{P}\left(\frac{d\,\mathrm{Q}}{d\,z} - \frac{d\,\mathrm{S}}{d\,y}\right) + \mathrm{Q}\left(\frac{d\,\mathrm{S}}{d\,x} - \frac{d\,\mathrm{P}}{d\,z}\right) + \mathrm{S}\left(\frac{d\,\mathrm{P}}{d\,y} - \frac{d\,\mathrm{Q}}{d\,x}\right) = 0,$$

the writers proceed to show that the equation given above connecting the electromotive force e with the current i does *not* fulfil this condition, and that it therefore cannot be integrated without more data being known. The simplest consideration of the physical meaning of the problem would have rendered this result evident without resorting to mathematics at all; for the equation applies to *any* circuit, and the electromotive force e may vary in *any* manner. A long proof is given, in Chapter XI., of the fact that the heating effect of an alternating current may be greater while the current is flowing in the positive direction than while it flows negatively. This happens even when the area of the positive part of the curve is equal to that of the negative part, provided the shapes of the two portions differ from each other. Such currents no doubt do occur, in arc-lamp circuits perhaps, but they are rare, and hardly merit much attention. In any case, however, the suggestion, made by the authors, that the inequality of the heating effects of the positive and negative parts of the current "may afford an explanation for the fact that in many cases one carbon of an alternating-current arc lamp is consumed more rapidly than the other, depending upon the way it is connected up," is curiously erroneous. Whatever may be the law of variation of the alternating current, this certainly passes through both carbons of the lamp. If the positive portion of the current only passed through the upper carbon, and the negative portion only passed through the lower one, the author's suggestion would apply.

The book is very complete. It discusses fully the action of circuits containing resistance, self-induction, and capacity, the measurement of alternating-current power, and the propagation of currents along cables with capacity and self-induction distributed along them. It contains more than a hundred figures, all of which are new, many of them representing numerical examples, and a great many of them, especially in the latter, or graphical portion of the book, consisting of original constructions. In preparing these, a considerable amount of useful work has been done. The general get up of the book is excellent. It is, however, unfortunate that the character of the book is so theoretical. Nowhere do we find it stated that the self-induction of the circuits occurring in practice is, in most cases, *not* a constant, owing to the presence of iron, and consequent hysteresis. Many of the proofs given in the book are rendered unsatisfactory from this cause. The printing, as already stated, is good. Nevertheless, we think it a pity to use the letter D, as is done throughout the book, for the differential operator d/dt, as it is so liable to be confused for an ordinary symbol of quantity when occurring among a number of other letters of the same type. Another objectionable feature of the same kind is the use of the two letters Im to signify $\sqrt{\mathrm{R}^2 + \mathrm{L}^2\omega^2}$. A single symbol would be much better to prevent confusing Im with an ordinary product of two symbols. The suggestion is made to use the word "impediment," for circuits containing both self-induction and capacity, to represent the ratio of volts to amperes, *i.e.*,

$$\sqrt{\mathrm{R}^2 + \left(\frac{1}{\mathrm{C}\,\omega} - \mathrm{L}\,\omega\right)^2}$$

where R is the resistance, C the capacity, L the self-induction, and ω is the quantity, $2\,\pi$ times the frequency of the current. Even if condensers were used much in practice, which is far from the case, we should not think any fresh word necessary. The well-known word, "impedance," which Mr. Heaviside proposed for a circuit containing self-induction, can quite conveniently be used for circuits whose inductance is partially due to the presence of capacity. It is undesirable to multiply names till their need is more apparent.

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SOME EXPERIMENTS ON THE ELECTROCHEMICAL EQUIVALENT OF ZINC.

BY JAMES ERSKINE MURRAY.

The experiments, of which I subjoin an account, were carried out at the suggestion and mainly under the direction of Mr. Thomas Gray, B.Sc., F.R.S.E., during the winter 1887-88, in the Physical Laboratory of Glasgow University. But as Mr. Gray left this country for the post which he now occupies in America before the results were collected and discussed, these are given entirely on my own responsibility.

As the electrochemical equivalent of copper had already been satisfactorily determined,* the simplest plan for the determination of that of zinc was to put several cells in which copper sulphate was electrolysed in the same circuit with some in which zinc sulphate was the electrolyte. In all these experiments there were six electrolytic cells, all in series, in the circuit; three with copper plates and solutions, and three with zinc. Thus the same amount of electricity passed through each cell in the series; and hence, from Faraday's law, determinations of the current, or of the duration of the experiment, were not required. The current was, however, observed in order to find the most suitable current density on the zinc plates. The electrochemical equivalent of copper being known, that of zinc was directly calculated from comparison of the amounts of copper and zinc deposited.

The method of experimenting was almost identical with that followed by T. Gray and A. W. Meikle in the electrolysis of copper compounds. The plates were polished with fine sand-paper. After polishing, the plates were dusted with a silk cloth, and then weighed. The copper plates having been prepared in the same way, all were placed in their respective cells and the current made. The duration of an experiment was usually about two hours, during which time the current was kept as nearly constant as possible.

Immediately on breaking the circuit the gain plates were removed from the cells and washed with pure water. They were then dried between folds of clean blotting paper, held before a bright fire for a short time, allowed to cool, and finally weighed.

The best results, as to appearance of deposit, at least, were got when the plates were used within an hour or less after polishing. Two loss plates and one gain plate were placed in each cell. On the gain plates the range of current density was from $\frac{1}{210}$th to $\frac{1}{30}$th of an ampere per square centimetre. On the smaller plates, with high-current density, the deposit becomes coarsely crystalline; on the larger it covers the plate only in streaks, leaving a considerable portion of the surface uncovered. In no case was a deposit which covered the plate uniformly obtained. But for this range of current density the deposit was always adherent. It was noticed that, after washing and drying, the parts of the polished surface on which there was no deposit seemed in many cases to be covered with a very thin and slightly brownish film.

The compound of zinc electrolysed was the sulphate. The stock solution, otherwise pure, had a large quantity of zinc carbonate in suspension, which, before the solution was used, was removed by careful filtration. The liquid was then diluted with pure water to a density of 1·4.

In order to determine the rate of gain or loss of weight due to the independent action of different solutions the following experiment was made:—Four zinc plates, numbers (1), (2), (3), (4) were used; (1) and (3) had a zinc electroplated surface; (2) and (4) were polished as for the experiments in electrolysis. After weighing, (1) and (4) were placed in a glass of the ordinary zinc sulphate solution which had already been used in several experiments, and therefore probably contained no free acid. (2) and (3) were placed in a glass containing about one-third of a pint of this same solution but to which one drop of concentrated sulphuric acid had been added. The plates were left in their respective solutions for twenty-three hours; and when taken out were washed, dried, and again weighed. By taking the sizes of the plates, and the differences in weight caused by immersion in the solutions into account, it was found that in the neutral solution the average gain per square centimetre per hour was $1{\cdot}3 \times 10^{-6}$ gramme; while in the acid solution the loss per square centimetre per hour was 5×10^{-6} gramme. In experiments K, L, M, a neutral solution was used; and in N, O, P, a solution slightly less acid than the above. In working out the numerical value of the electrochemical equivalent of zinc from each experiment, the equivalent of copper was taken as 0·0003287 gramme per ampere per second, which is the value given by Mr. T. Gray for a current density of $\frac{1}{30}$th ampere per square centimetre, and conditions of solutions such as existed in these experiments. The electrochemical equivalents of copper and zinc being in the same proportion as the deposits of copper and zinc, the latter equivalent is easily found by a simple proportion sum.

Looking at the table of results, it should be noted that in experiments K, L, M, the zinc sulphate solution must have been neutral or nearly so, while in N, O, P it was slightly acid. Hence, according to the experiments on the action of such solutions, described above, the real value of the numeric should lie between that given by experiments K, L, M, and that given by the experiments N, O, P. Now the average value of EZn, calculated from experiments K, L, M, is 0·0003391; that from experiments N, O, P, is 0·0003381. It is safe, therefore, to take the value 0·0003386 of a gramme per ampere per second, as an approximation to the true value.

—	Duration of exp.	Zinc. Surface. Sq. cms. per amp.	Zinc. Deposit. Grammes.	Copper. Surface. Sq. cms. per amp.	Copper. Deposit. Grammes.	Current.	EZn. Grammes per amp. per sec.
	hr. m.						
K	1 12	(1) 125	0·3597	(1) 75	0·3483	0·25	0·0003388
		(2) 105	0·3590	(2) 50	0·3488		
		(3) 85	0·3591	(3) 45	0·3486		
L	2 0	,,	0·6181	,,	0·5988	,,	0·0003392
		,,	0·6186	,,	0·59-1		
		,,	0·6175	,,	0·5990		
M	1 43	,,	0·5317	,,	0·5151	,,	0·0003393
		,,	0·5318	,,	0·5152		—
		,,	0·5317	,,	0·5151		
N	1 25	(4) 210	0·4551	(4) 190	0·4412	,,	0·0003385
		(1) 125	0·4546	(1) 75	0·4421		
		(2) 105	0·4553	(3) 45	0·4421		
O	1 30	,,	0·4499	,,	0·4365	,,	0·0003380
		,,	0·4490	,,	0·4376		
		,,	0·4500	,,	0·4377		
P	1 30	,,	0·4659	,,	0·4517	,,	0·0003379
		,,	0·4644	,,	0·4531		
		,,	0·4658	,,	0·4532		

A SIMPLE EXPERIMENT.

To obtain those luminous tube effects which created so much non-technical bewonderment last year, Mr. Nikola Tesla employed a whole armoury of appliances, including a special high-frequency alternator, oil transformers, and special magnetic interrupters. Mr. Nikola Tesla no sooner showd us how to do the thing in an elaborate manner than, as is invariably the case, everyone was showing everyone else how to obtain similiar effects by the most simple contrivances. The limit in this direction appears, however, to have been reached by M. P. Marsillac, who, in *La Lumière Electrique* for April 22nd, described the following rudimentary arrangement.

M. Marsillac employs three Lalande and Chaperon cells of the French telegraph pattern; a Ruhmkorff coil ten centimetres long by 3in. diameter, with an extra sensitive trembler break, and a thin-glass Geissler tube 10 or 15 centimetres long. With this toyshop apparatus, M. Marsillac is able to reproduce one of the most striking of Mr. Tesla's experiments. Shades we had all known increased the effective illumination obtainable from a given source of light, but when on that historic Thursday evening, at the Royal institution last year, Mr. Tesla applied a shade to one of his single-wire glow lamps, the candle-power of the lamp went up as well the candle-feet on the table below, we seemed to be getting dangerously close to perpetual motion in the shape of an indefinitely large amount of light derived from an indefi-

* T. Gray, *Phil. Mag.*, November, 1886, and March, 1888.

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nitely small source of power. It is this pretty electrostatic experiment that M. Marsillac reproduces with the simple appliances above mentioned. He connects one terminal of the tube

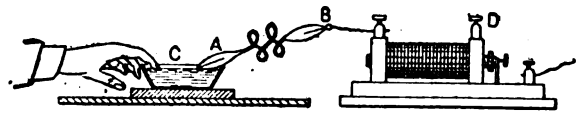

FIG. 1.

to one terminal of the coil, as shown (Fig. 1), having previously filed down the other tube wire, and dips the free end of the tube into a little china dish, C, resting on a sheet of ebonite, and containing either pure water, salt water, sulphate of copper, &c., &c. On dipping the finger into the liquid the tube commences to glow. Once started in this way the glow persists even if the finger is

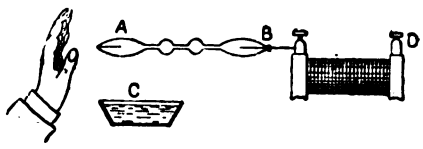

FIG. 2.

withdrawn from the liquid. On lifting the tube out of the liquid (Fig. 2) and bringing the hand up close to it the glow also continues.

THE HANOVER CENTRAL STATION.*

The Hanover central station, one of Messrs. Schuckert's design, was contracted for on May 2, 1890, and opened on March, 3, 1891. It offers several points of interest. The method of regulation and distribution by means of secondary cells has been adopted, and has been developed to such an extent that in this case the accumulators are of as much importance to the supply as the dynamos themselves. The station was designed to supply current to a load of some 50,000 8-c.p. lamps, and an enlargement took place last year. The boilers and engine house are of the usual type, and do not merit any particular description. The engines and dynamos, on the other hand, are more interesting. The former are triple expansion condensing engines, the three pistons working on a common shaft by means of three cranks at 120deg. from one another. This arrangement, shown in Fig. 1, is said (in combination with the flywheel action of the armature) to produce a very steady running combination. There are three engines, two of 300-400 H.P. and one of 500-600 H.P. Since the shaft rests on the bedplate of the engine, and the dynamos are direct-coupled, the floor of the engine-room is on two different levels, the dynamos being on the lower level. The regulation of the engine is said to be exceedingly good.

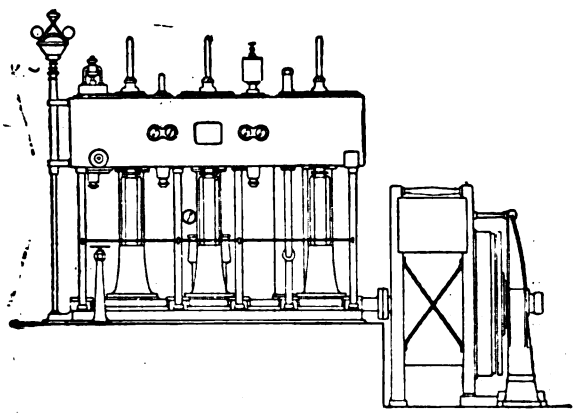

FIG. 1.—Hanover Central Station : Engine and Dynamo.

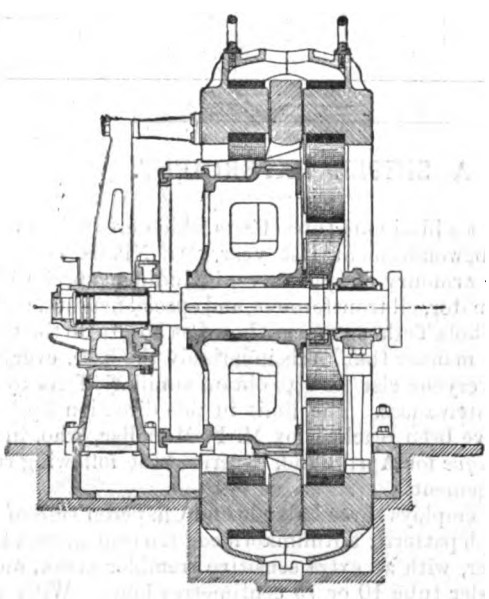

FIG. 2.—Hanover Central Station : Section of Schuckert Dynamo.

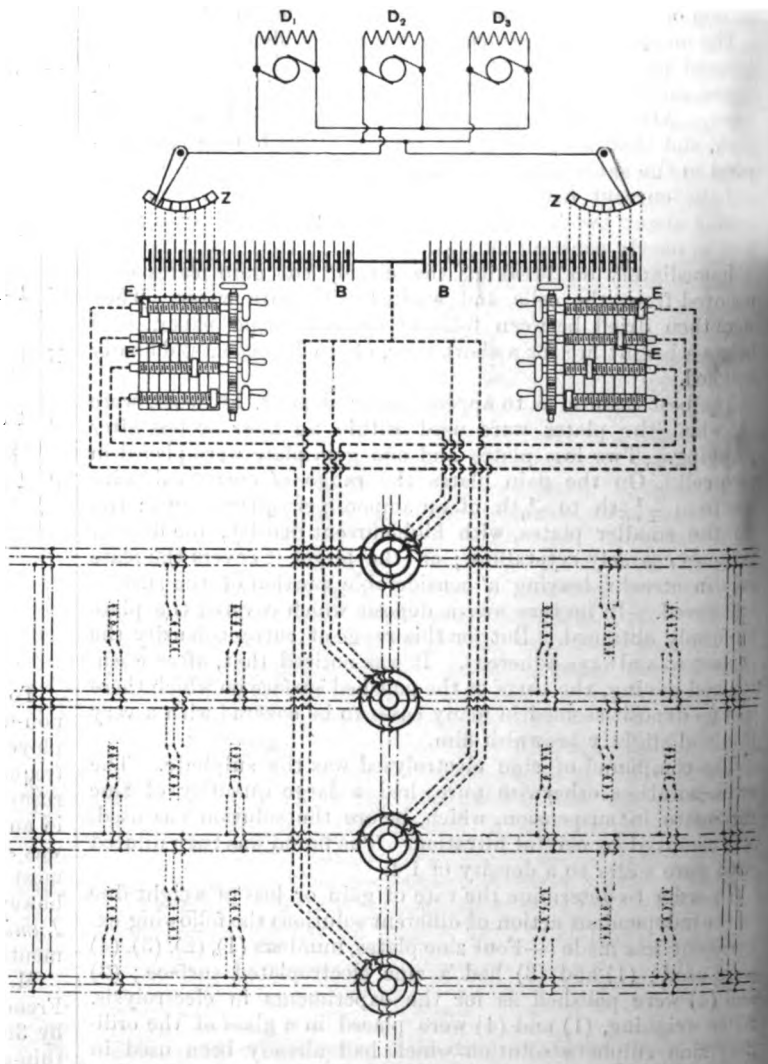

FIG. 3.—Hanover Central Station : Diagram of Distributing Arrangements.

The dynamos are ring armature machines of the multipolar type, and the current is collected by eight sets of brushes. The commutator has 840 segments, and is 6ft. 6in. in diameter. The output of each of the old machines is 275 kilowatts, and of the new one about 400 kilowatts. Fig. 2 gives a section of one of the machines.

* From the *Elektrotechnische Zeitschrift*. We are indebted to Messrs. Schuckert and Co. for the loan of some of the blocks.

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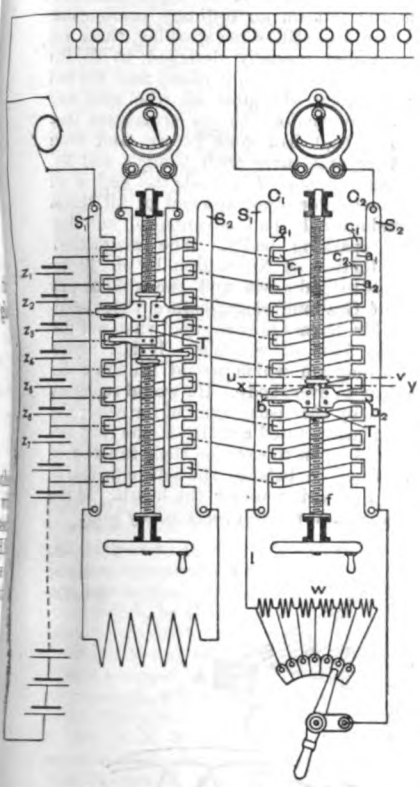

Fig. 4.—Hanover Central Station: Diagram of Discharging Switch.

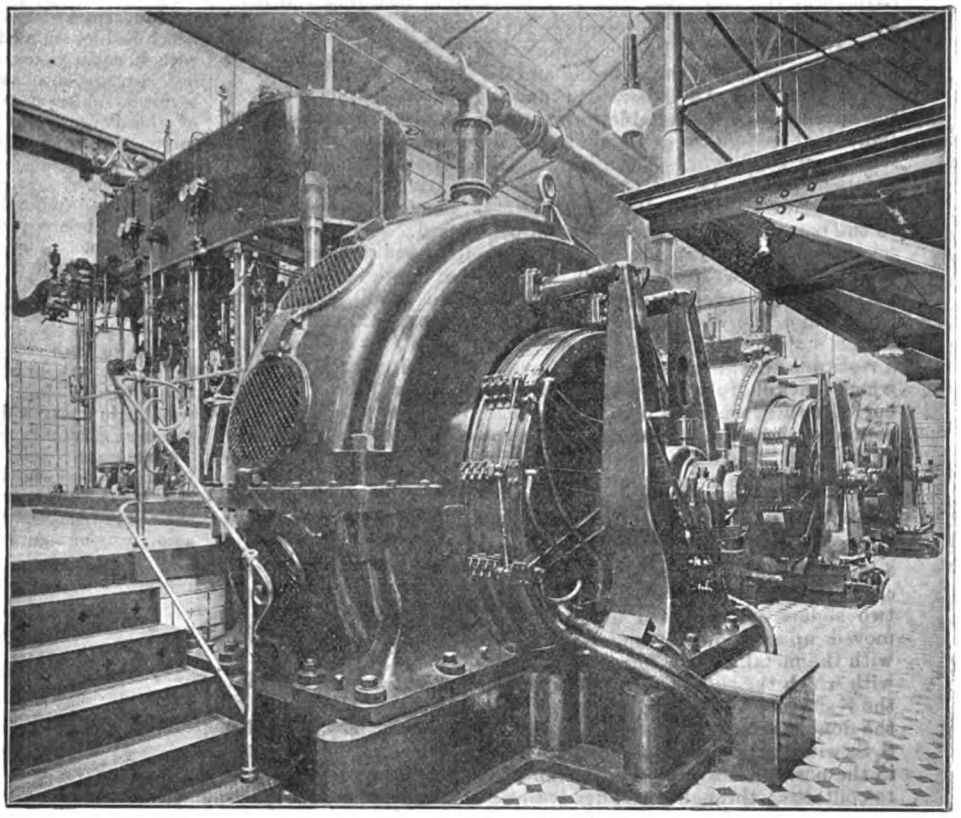

Fig. 5.—Hanover Central Station: View of Dynamo and Engine Room.

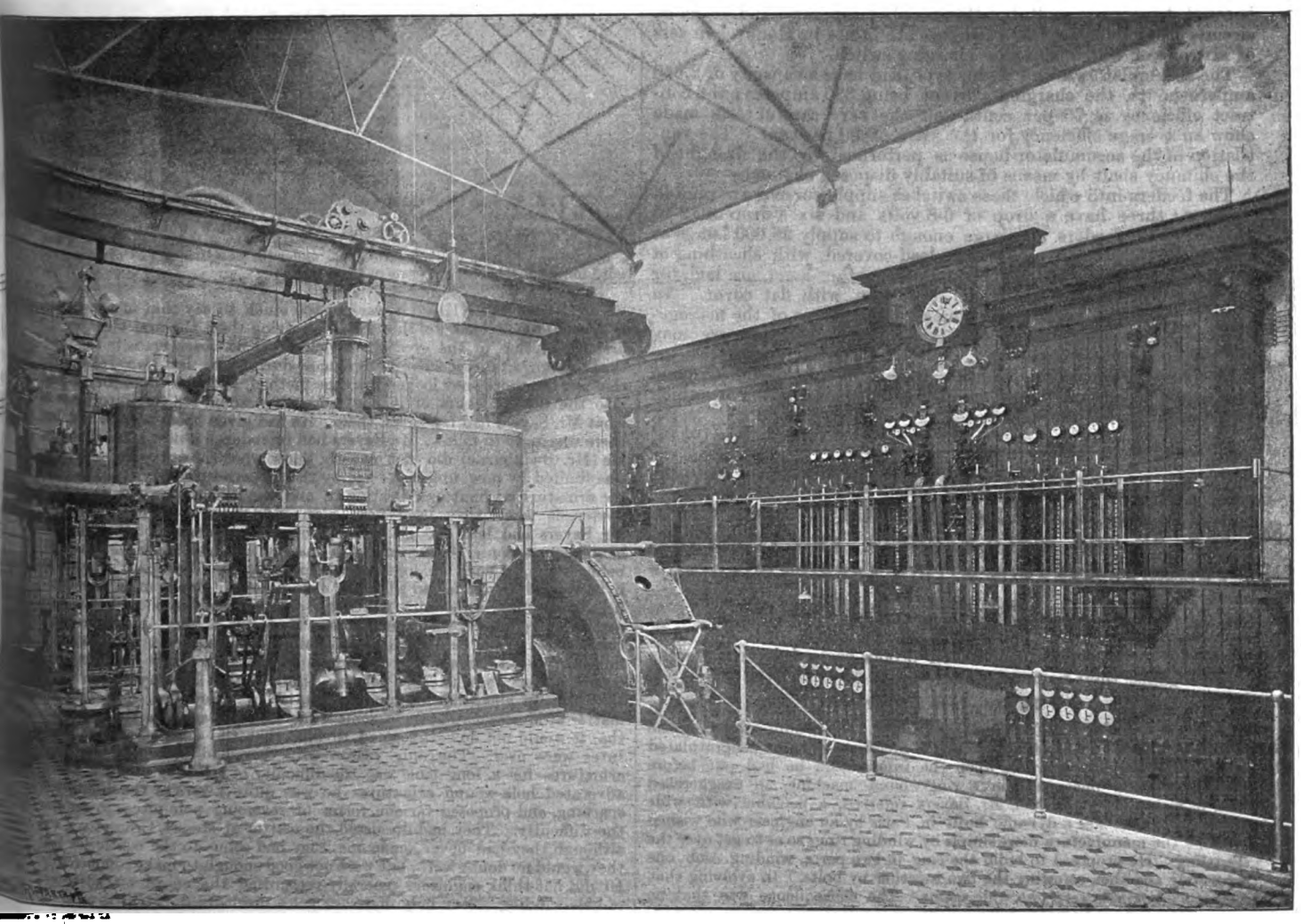

Fig. 6.—Hanover Central Station: View of Dynamo and Engine Room.

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The system of distribution is an improvement on that used at Barmen by the same firm, and is a method of charging the cells with the dynamos and discharging them into the feeders at the same time in the well-known manner; it is done here, however, on a large scale, and the charging and discharging switches are of ingenious form. An elaborate argument is entered upon to show the advantages of being able to separately regulate the pressure on individual feeders, so as to allow for different drops in different lengths of conductor. The diagram (Fig. 3) shows the arrangements:—D_1, D_2, D_3 are three dynamos in parallel; Z Z are the charging switches; B B the accumulators. The feeders are coupled to the batteries, a three-wire system being used. The feeder connections are, as shown, mounted on spindles, and are capable of independent movement, as well as combined motion, to take up variations of pressure due to differences in condition of cells. The form of the discharging switches is the most interesting point in this station. It is obviously necessary to use two contacts with a resistance between, in order to avoid short-circuiting the cells when moving from one contact to another, and with very large currents this resistance becomes too large to move about with the contact-maker. Again, since the pressure of the contacts must be very great to ensure absence of resistance and of heating, the insulation between the contacts gets rapidly worn away. These two objections have been met by the arrangement shown in Fig. 4, in which z_1, z_2, z_3 . . . are the cells, connected to the contacts c_1 c_2. . . . These contacts form, with the metal-piece a_1 a_2 . . . a metallic bed C_1 for the slider b_1, and similarly on the other side c_1 c_{11} . . . and a_1 a_{11} . . . form a bed C_2 for the slider b_2. These two sliders are mounted on a common block T, which can be moved up and down by means of the screw spindle *f*. In parallel with the metallic beds formed by a_1 . . . c_1 . . . are strips S_1 S_2, with which the sliders always make contact. Between S_1 and S_2 is the resistance *w*, which prevents a short circuit of the cell. By the double arrangement shown in Fig. 5, a_1 a_2 . . . may be part of S_1 S_2 without producing a short circuit. The circuit is as follows in the position drawn:—The current starts from the cell z_6, gets to to contact c_6, through the slides b_1 to S_1, through *l* to *w* the resistance, thence to S_2, and through the ammeter to the feeder. If the contact is across the line *x y*, the current goes from cell z_6 to C_{11}, thence through the slides to S_2 and to the feeder, the resistance being then cut out. In the intermediate position *u v*, the resistance is coupled across one cell, but this is only temporary, and no short circuits are possible. These switches are in use in Hanover in sets of six, one of which is used as charging switch.

The accumulators are of Tudor type, and have a capacity of 2,640 ampere hours, the charging current being 330 amperes; the contract efficiency is 70 per cent., but the very careful tests made show an average efficiency for the year of 80 per cent. The ventilation of the accumulator-house is performed by the draught of the chimney-shaft by means of suitably disposed channels.

The feeders into which these switches supply current are nine in number; three have a drop of 6-8 volts and six a drop of 12-15 volts. These feeders are large enough to supply 28,000 lamps at one time. The cable network is lead-covered, with sheathing of galvanised iron tape. The feeders, on the other hand, are laid, for mechanical protection, in channels of U iron, with flat cover. An extensive system of statistics is one of the features of the management of this station, and to this system and its results we may refer at some future date.

The illustrations (Figs. 5 and 6) show two views of the dynamo and engine room, and give some idea of the large scale on which the station has been designed.

ON THE PREVENTION AND CONTROL OF SPARKING; CONTINUOUS-CURRENT DYNAMOS WITHOUT WINDING ON THE FIELD-MAGNETS, AND CONSTANT-PRESSURE DYNAMOS WITHOUT SERIES WINDING.*

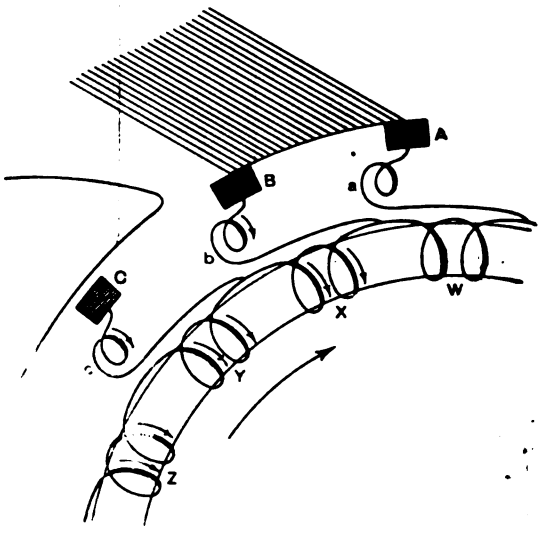
BY W. B. SAYERS.

DISCUSSION.

Speakers who have returned their proofs revised have asterisks placed against their names:—

THURSDAY, MAY 11TH.

*Prof. SILVANUS THOMPSON said he felt he was only expressing the sentiments of the whole of the assembled members when he congratulated Mr. Sayers upon his Paper and upon the information he had put before them. He had once seen in a ring-wound machine, an exaggerated case, in fact, of that to which Mr. Sayers referred, a machine with wide driving-pegs. It was a dynamo built in Paris by an engineer who wished to make the manufacture more simple by winding rings so as to get over the shuttling. He proposed to build the ring in two parts, winding each one separately and then screwing the two together by bolts. In evolving that mechanically there were two wide seams. The consequence was that he designed the commutator to match; it had 20 parts in one side and 20 parts in the other, with wide angular spacings to match the coils. The machine sparked most abominably. He then took off the commutator which had its segments spaced out, and put on an ordinary commutator with 40 equal pieces, and though there was still some sparking, there was less sparking than with the commutator specially designed to fit the segments of the armature. With respect to the point raised near the end of the Paper about the narrow air-space, of course all who took any interest in the details of machines were anxious to see armatures that should be more mechanical than those that had gone before, and when Mr. Swinburne first brought out those armatures with tunnels and Mr. Brown began to build them in Switzerland, they felt that the end of all things had been arrived at But somehow or other the end of all things had not come. Those armatures undoubtedly had advantages, but they still possessed the disadvantage of sparking badly. The magnificent machines designed for aluminium reduction at Neuhausen by Mr. Brown had to be sent back and the core discs turned down and the winding put outside, as in the ancient winding of Gramme rings, before they would consent to work without sparking. Mr. Sayers now showed what was the legitimate way of returning to that form of winding. If Mr. Sayers would pardon him, he would draw a diagram which would illustrate the winding in a way which would be clear to everybody. He would represent the successive coils of the armature by the usual symbol for cells; the "commutator" cells being not in the main closed circuit of the ring, but being each on open circuit until called upon to exercise their function of creating a sufficient electromotive force to balance the self-induction of the coils which are to be reversed in passing under the brush. In the accompanying figure the symbols for cells have been replaced by coils.



W, X, Y, Z, Sections of Armature Winding. *a*, *b*, *c*, Commutator Coils to furnish the E.M.F. necessary for Sparkless Reversal. A, B, C, Bars of Commutator. The Arrows represent E.M.F.'s, not Currents. The Current in W, which in passing under the brush has to be reversed; and this is effected by the E.M.F. of the coil *b*, which is still actively cutting the Magnetic Lines under the Pole, hence can overcome the Self-Induced E.M.F.'s of the Current in W.

*Mr. SWINBURNE said it was not too much to say that in a few years they would look back to this Paper as giving them the first hints, or the first description, of the greatest advance that had been made in the practical design of direct-current dynamos during the last ten years. He thought the more they looked into the method, and the more they looked into the developments of it, the more they would see the importance of what Mr. Sayers had not given them. He had given them a great deal, but there was more to follow. Mr. Sayers had introduced a new state of things. He (Mr. Swinburne) did not exactly know what the output of a dynamo was limited by now, unless it was by the ampere-turns they could get on the armature without over-heating it, and the difficulty which arose from hysteresis when they used very high inductions. He did not think Mr. Sayers had laid enough stress upon the importance of the smallness of the connections. A drawing of a machine such as Mr. Sayers had put before them, or such an ingenious diagram as Dr. Thompson's, looked as if it would be complicated when put into practice. But it must be remembered that those wires with the little auxiliary coils in them had only to carry a current for a very short time. That was a very important practical matter in the design of those machines. As regards the spaced commutator, he did not want to be critical where they ought to be entirely congratulatory, but he could not help thinking that Mr. Sayers was wrong theoretically about his dummy commutator. They had gone into the matter at Messrs. Crompton's some time ago, and came to the conclusion that it would not do. It seemed to him that the days of smooth armatures were over. The only reason why they had not had hole-wound armatures for a long time was the difficulty of sparking. When he first advocated hole-wound armatures he was quite aware of the difficulty of sparking, and proposed various forms of reversing pole-pieces to get over the difficulty. They had discussed the matter at Messrs. Crompton's, and although they had never made one, they had come to the conclusion that they would no doubt work, but were not good enough to make commercially. He did not think engineers generally recognised the enormous advantage of hole-winding. Not only did they get a mechanical machine, an armature they could take out and roll about the floor without hurting it, but

* Paper read before the Institution of Electrical Engineers, May 11th.

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they got rid of the Foucault currents; and above all, when working with a hole-wound armature, they had no mechanical forces on the armature wire. The whole of the mechanical force came on the iron, and that was a matter of very great importance when they were dealing with insulation. They had no longer to get their torque communicated through cotton, shellac, and messes of that sort. He would ask them to read the last sentence of Mr. Sayer's Paper again, and to believe it.

*Mr. HOUSMAN said that some eighteen months or so ago he made a number of experiments at the works of Messrs. Willans and Robinson, which to a great extent bore out the conclusion that the average current in the commutated section might be extremely large in some cases. There was a point in connection with the commutation which was too often lost sight of, and that was the extreme importance of the surface resistance between the surface of the brush and the surface of the commutator. If the brushes were not placed in the proper position they had all the current crowded up into the front part of the brush, and there was a very considerable fall of potential at the tip, while at the heel there was no current, and consequently no fall of potential, and there was an E.M.F. round the circuit tending to help the reversal of the current. In the case of ordinary copper brushes the surface resistance was about the 1/400th of an ohm in a square inch; in the case of carbon brushes it was three or four times greater so far as he could measure. He found that, with the ordinary working full load of a dynamo and copper brushes, they might have a fall of potential of 0·3 or 0·4 volt between the brush and the commutator, and by shifting the brush forward and backward, in advance of and behind the best position they might have a difference of potential between segments under the brush of about half a volt or so in some cases, and that half-volt represented a reversing E.M.F., which had in a very much smaller degree something the same effect as Mr. Sayers's invention. The same thing might be produced to almost any extent by having the connections from the armature windings to the commutator made of high resistance. In the case of carbon brushes, he thought one of the principal benefits of them was that if the current was crowded up into the tip it did not stick to the commutator in the way that copper did if overloaded. It was often to be noticed that if a copper brush was overloaded the commutator immediately began to get rough, which he thought was due to the fusion of the point of the brush owing to the current being crowded up to the tip.

*Mr. W. M. MORDEY said he had not fully grasped the Paper yet, but he was glad that Mr. Swinburne had said what he was going to say, that it was of great importance, and that came very well from Mr. Swinburne, who had done, perhaps, more than anybody to lead up to the results that Mr. Sayers had obtained. This was one of the most pregnant and suggestive Papers on direct-current dynamos that they had had since the two Hopkinsons' Paper in 1886, and he was quite sure that the last words of the Paper were justified; Mr. Sayers had touched on the border of a new field of design, and they would see a great deal done in that direction. No doubt the result that he had arrived at could be traced back step by step. He thought it was nearly always the case that, when any real advance took place, everybody said it was a very simple thing and wondered it had not been thought of before. That was the kind of thought many of them had had that night. One must condole cordially with the writers of columns of mathematics on dynamos who had never arrived at any such practical result. Yet he thought it might, perhaps, be possible to go a little too far in following out this direction. He wanted to get information upon that point; he did not quite see the necessity of having all the excitation on the armature. In some ways it was the best place to have the excitation, but in others the worst. It was the place where they could least spare space; they could not work with a nice low-current density there as they could in the field. There, in the machine before them, for example, they had the field coil giving the initial magnetisation. He should like to know what the difference in the current density was in the armature considered as an exciting coil and in the field considered as an exciting coil, because he thought it would show how much more economical a certain portion of the excitation would be as regards energy if placed on the field-magnet in the ordinary way. It had been asked what the limit was going to be. He supposed Mr. Sayers would say simply the heating. If a machine were self-regulating and sparkless, with no drag on the conductors, he thought there was no limit except heating. Certainly the efficiency would not suffer. Was it not the fact that with high-pressure direct-current machines, hole-wound, or tunnel-wound armatures were rather difficult to wind? The machines that had been wound in Switzerland had all been low-pressure machines, and there was nothing to do but put a solid bar of copper through the holes and insulate them. This was an enormous advantage, but he was not at all sure that it would be found possible in small machines, at any rate for rather high pressures, to wind them through holes in that way.

*Mr. S. F. WALKER said he was about to take the unthankful office of throwing cold water on the Paper from the practical manufacturer's point of view. Before doing that, however, he would call attention to the great inconvenience to members of not having proofs of the Paper. Above all others, that was a Paper they ought to have had weeks before. Dealing with the Paper, he said he found fault with the channels and with the low clearance from the practical point of view. It was very difficult to insulate the wires properly when they were in a channel. He found fault most strongly with the small clearance. He should be surprised if Mr. Sayers had not found the armature touching a great many times. Good fitting, of course, would do a great deal, but they had to consider not only the fitting but the hands the machine had to go into. They had to consider that the spindles would bend unless they were very stiff, and other problems, and to a certainty they would get the armature out a little bit, and it would be running on the poles from time to time, and do more harm than good. All these devices for reducing the sparking and increasing the efficiency—were they worth the candle? When they got 1 or 2 per cent. efficiency, was it real efficiency? Was not the real efficiency what it cost to maintain, that was, the interest on its first cost, *plus* the cost of coal, and so on? It was an old engineering principle that when you got beyond a certain point every 1 per cent. cost more than it was worth. Engineers welcomed Papers of this kind and improvements of this nature, because, though they were rarely permanently successful, they advanced the standard at which real efficiency began.

THURSDAY, MAY 25TH.

*Prof. W. E. AYRTON said Mr. Sayers's Paper interested him very much, because it revived an old notion which Prof. Perry and himself put forward some years ago of using the armature field of a machine to help the field. Mr. Mordey, in the remarks he made, raised a doubt as to whether a certain amount of power for magnetising could be more economically employed in the windings of the armature than in the windings round the field-magnet. That, he thought, was not the proper way to look at the matter. It was not a question of whether it was more economical to produce a field by directly exciting the armature than by directly exciting the field-magnet. It was whether it was more economical to produce a field F + A by exciting the magnet, and a field − A by means of the armature, which was what was usually done, or simply to produce a forward field F by the armature. There could be no doubt as to the answer. It was more economical to produce the resultant field F by one magnetisation than by two opposing magnetisations F + A and − A. He (Prof. Ayrton) made tests ten or eleven years ago in Paris by measuring the efficiency and power of a motor with various leads. The more the lead was forward the better, as regards efficiency and power. In May, 1883, he showed at a lecture at the London Institution that, with a forward lead of the motor, it was not necessary to excite the field-magnet at all. A little later on, Dr. Hopkinson gave a Paper at the Royal Society on an analogous experiment, namely, that with a back lead a dynamo could be made to excite itself. But the orthodox makers of dynamos, perhaps not unnaturally, objected to this arrangement. How did Mr. Sayers look at the matter? By his device Mr. Sayers had succeeded in commutating his coil, not where it was usually commutated, but where it was best to commutate it. He had annihilated the sparks by an auxiliary device. The only difficulty in the arrangement was that whilst it was extremely compact, and, he doubted not, extremely satisfactory in its operation, it had the disadvantage that part of the main armature was wound with wire which was not operative in producing the main external electromotive. They had to have a number of auxiliary coils merely for the purpose of neutralising the spark and reversing the current. There were other plans which had been thought of for producing the same result. One plan, of course, was to have an auxiliary electro-magnet, or they could shape the field-magnet in a particular way at the place where they wanted to commutate. The worst plan of all, he thought, was the ordinary plan of commutating in the wrong place, simply because at that place there happened to be an electromotive force naturally introduced which would reverse the current. There was a plan which Prof. Perry and he discussed some years ago which might be worth mentioning. It was to introduce a completely external electromotive force by using two very narrow brushes close together to form the main brush, and a resistance inserted which could be adjusted; this electromotive force being produced by an accumulator or other convenient means. The auxiliary resistance and electromotive force were made sufficiently large, so that the current set up by the accumulator was not much larger when the two parts of the double brush touched one piece of the commutator than when they touched two. He thought Mr. Sayers was very much to be congratulated upon having revived what he ventured to think was the right principle in making a machine, and on having introduced a very ingenious contrivance to enable that right principle to be utilised without the destructive sparking which had always hitherto accompanied its adoption.

*Mr. ALBION T. SNELL wished to add his congratulations to those already given to Mr. Sayers for the neat solution he had given of a very interesting problem. The problem was, of course, an old one; he himself, as many as nine years ago, working with Mr. Swinburne, tried the plan Prof. Ayrton had put on the board, but it was not successful, owing to the diameter of commutation not being fixed. He was sorry Mr. Sayers had hitherto only applied his device to Pacinotti armatures, for he was under the impression there were considerable mechanical difficulties in applying it to smooth-cored armatures. He had tried toothed-core armatures, and after an extensive experience had gone back to the smooth core. He thought Mr. Sayers would have to do so too. There were two objections which struck him in connection with this application, and the first was the question of heating. At the present moment the limits to the output of a large dynamo were two. The first was sparking and the second heating. His experience, at any rate, had been that the output of a large armature was practically limited by the heating. The heating effect in the commutator coils was small, but he was afraid they were putting their compound coils in the wrong place. If they put them on the field-magnets they might have to use more wire and expend more energy, but the heat expended there could be readily controlled, whereas if the armature were already overheated it was not easy to do so. The largest armature Mr. Sayers had built so far appeared to be a 40-unit one. It was exhibited downstairs. He had roughly calculated the output by slide-rule, and estimated it to give something like 35,000 watts. If the stated output were correct, the objections which he raised did not seem to have much weight. There was one application of Mr. Sayers's principle which struck him at once, and that was its application to motors. The problem of motors, particularly series wound for traction work, had been complicated very much by questions of weight, and although in stationary machines weight could be neglected, on a tramcar it could not, and if they could lessen the weight of a machine by 15 or 20 per cent. by means of this device—and it seemed quite possible—a very material advance was marked in connection with motor design.

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He would also point out that the device seemed to be chiefly applicable to series-wound machines, for in that case there was a possibility of entirely doing away with the excitation, but in connection with compound-wound machines they could only, at the best, hope to do away with series coils. From a conversation he had had with Mr. Sayers he gathered that so far as he had experimented with compound machines, he (Mr. Sayers) got a straight line, whereas in practice, what they wanted was not a straight line but a slightly ascending characteristic. So it appeared to him (Mr. Snell) unless the number of commutator coils were increased, they would still have to use series turns on the field-magnets, and the question was whether by using turns on both armatures and field they would gain much. Mr. Sayers's device undoubtedly marked a considerable improvement in the design of direct-current motors and dynamos, and he could not help thinking that manufacturers would not be very pleased to see it introduced, for it must have the effect of depreciating old stock.

Prof. GEORGE FORBES said it might be worth while mentioning, in connection with the introduction of secondary coils to overcome sparking that he had lately seen a dynamo in which that device was employed, but to get over a somewhat different difficulty. It was the device of one of the most ingenious of the American electricians, Mr. Eickemeyer, who made use of it to stop the sparking at the brushes of a direct-current series-wound motor, with laminated field when working from an alternating circuit, especially at the moment of starting.

Mr. ALEXANDER SIEMENS was astonished at the title of the Paper, because he thought sparking at the brushes was ancient history, and that modern dynamos did not spark. This device introduced complications which, from a manufacturer's point of view, were very objectionable. He spoke principally, of course, about the drum armatures, with which he was most acquainted. The object which a manufacturer must have in view was that he should give a good machine, which would produce a given output at the least cost. He could not go in for fancy work, and this extra winding which was to be put on the armature was certainly taking up useful space. If they were to adopt this device it should be clearly shown that it was cheaper to use it than to adhere to their ordinary construction. Several speakers had spoken of the sparks as great enemies, and all that sort of thing, but he wished to emphasise the fact that it was not nowadays at all difficult to make dynamos which would run sparklessly under any load and without any change of the position of the brushes. It was just the same with motors. It was not necessary for motors to spark, so long as they were not absolutely overloaded, and he did not see the use of such an application at all. It might do all Mr. Sayers said. He had certainly done good work in making the experiment, and showing what could be done in that way; but he entirely doubted the utility of the device from the manufacturer's point of view.

Mr. CHAMEN said he had seen the machine described in the Paper. It was wound to act entirely as a regulator, and was constructed to give about 13 volts when running with a current of about 40 amperes, or something like that. It was driven by a separate motor, and used in series with the main dynamo, or in series with the feeder, which carried current for a large number of lights to a considerable distance. It therefore acted as an ordinary series dynamo would, though, perhaps, considerably better, and gave a necessary increase in the voltage of the generating station, so as to make the voltage throughout the run exactly constant. It worked perfectly, without any sign of sparking. It was not working at full load when he saw it, only at about 30 amperes, but it was quite evident that it would work without sparking.

*Mr. MORDEY did not think the real point of Mr. Sayers's Paper had been grasped. Mr. Sayers enabled them to approximate a direct-current dynamo to a transformer. The excitation of a transformer required very little energy indeed; they were able in a transformer to do without any air space, and air space cost money, because they must supply energy to force the flux through it. It seemed to him that Mr. Sayers's Paper enabled them to get a very small air space, a mere mechanical clearance, that reduced the ampere-turns from thousands to hundreds. The ampere-turns on the armature must be there anyhow. If they could be used for the excitation of the whole machine, so much the better. He quite agreed with Mr. Siemens that modern direct-current machines ran sparklessly, but at what a cost! Look at a good modern two-pole or four-pole dynamo—at the amount of copper on it—at the many thousand ampere-turns necessary to get the magnetisation of the armature, at the magnetic field, and at the necessarily inefficient way in which they must apply the copper on the fields, the large quantity of it outside, and practically useless, mere end connections! It seemed to him that the real point was that they got rid of that great air space without losing the great advantage of non-sparking, and got rid of the necessity of putting a large amount of copper on the field, and paying a lot of money for that copper.

*Mr. CROMPTON said he should like, as a fellow manufacturer of dynamos, to corroborate what Mr. Siemens had said, without wishing in any way to dishearten Mr. Sayers in carrying on his most interesting experiments, which, no doubt, would be of very great value to them in the future. He wished to point out to him that Mr. Siemens was right in trying to keep before him the fact that the problem was solely one of expense. The dynamo machine had already arrived at sufficient perfection as regards the user, but it cost money to make, and if Mr. Sayer's improvements really had the effect of reducing the material and labour required in producing the dynamo or motor of a certain output, then he had achieved a great step in advance; but it was on that one point—and it was the sole point—on which they would ask him to throw light. Mr. Sayers was working at a problem which had been before dynamo makers for the last six or seven years, that of reducing the air space. The difficulty that had ruined that idea in the hands of everyone who had undertaken it, was the sparking—and when he mentioned the names of Swinburne, Brown, Ganz, and others, all of whom had made sunk windings on the armature, and all of whom had more or less failed—Mr. Sayers would see that the problem was one that had engaged their earnest attention, and if by his invention, and without extra expense, he did enable them to reduce air space, he had, indeed, made a great advance.

*Mr. SWINBURNE said it must not be taken for granted that this form of winding could only be used with hole winding. He was not at all sure about that. If a smooth core was used, there was, of course, a large air space; if there was a large air space it took less electromotive force to cause a reversal in the section; and, at the first blush, it seemed that they ought to be able to succeed almost as well with smooth as with hole-wound armatures. Of course, if they had a smooth-wound armature there was considerable difficulty, as the commutator connections all came so close together that it was difficult to have one connector out of the field while the other was in the field. He would like to hear how far it was possible, by lessening the number of commutator connections, to get over that difficulty. He did not know whether increasing the number of turns per section would increase the electromotive force available for reversing quickly enough. He hoped Mr. Sayers had worked it out carefully, and would tell them the result. Prof. Forbes had referred to the difficulty of making a series alternating motor of a simple series-wound direct-current machine with laminated fields. There were two main difficulties: The first was due to the self-induction of the machine. That induction could be overcome, to a certain extent, by condensers. But that was a serious objection; people did not want to put condensers in their houses with motors. The other difficulty had not been very fully realised. That was the objection of the sparking at the commutators. He thought that might be got over by winding the armature double, as was sometimes done for large currents; in that way they would have two complete circuits round the armature. If their brushes were only the breadth of one section, they never short-circuited a section, they simply passed from one armature circuit to the other. At first it might sound as if he were proposing to only half utilise the armature, but the two circuits were only out of parallel when changing from one section to the other.

*Mr. A. P. TROTTER wished to emphasise the remarks of Mr. Mordey by asking Mr. Sayers to incorporate in his reply, as printed, an estimate, or outline design, of a dynamo with his appliance, and of a dynamo as constructed according to the best theories.

*Mr. SAYERS, replying to the discussion, said he did not know in what terms to express his appreciation of the exceedingly kind way in which his Paper had been received. Dr. Thompson had very kindly suggested a diagram which was very highly appreciated. His (the speaker's) own diagrams did not seem to have been very easily understood. He thought he might say that, if those diagrams were difficult to understand, they represented everything that happened, and that was not true of any other diagrams that had been suggested. Another point of Dr. Thompson's was the use of a dummy section where driving pins were used. Mr. Swinburne also referred to the dummy section, and confirmed Dr. Thompson's view that it was useless. He (Mr. Sayers) had not tried it; he did not believe in armatures with irregularly spaced windings, but he had offered the idea to those who seemed still to find it necessary to adopt irregularly-spaced windings. Mr. Swinburne thought they might be troubled in future with his (Mr. Sayers's) arrangement, with hysteresis in the flux horn. He, however, had never found the slightest sign of heating, either in the flux horn or any other part of the field-magnet surface, provided the air space was not less than two-thirds of the width of the slot. He would qualify that by saying that it was also necessary that the area of the teeth should be sufficient to carry the induction. He thought that was a point which had been overlooked by some of those who had spoken, especially those who complained of the heating of the teeth. He had never found that the teeth in slotted armatures heated at all, and he thought the reason was that he had always observed the necessity for making the sum of the area of the teeth equal to the cross-area of the core. They had a certain amount of induction to pass through the armature, and, if they were going to pass it through the teeth, it was quite evident that they must be as careful in making the teeth large enough to carry the induction as they were in making the core large enough. He was very much obliged to Mr. Swinburne for pointing out that in a slotted armature there was no force exerted on the wire; that was a point which had not occurred to him, but it certainly seemed a very strong one in favour of a construction in which the wires were either wound through holes or in slots. Mr. Mordey suggested that it was of no practical use in putting the whole of the excitation on the armature. He (Mr. Sayers) quite agreed with him, more especially with regard to small machines. The reactions upon which he depended in his device would be greater in large armatures than in small ones. The large machines had behaved quite as well as, if not better than, the small ones. Mr. Mordey also thought there would be difficulty of insulation. He (Mr. Sayers) admitted at once that he had never made any very high-pressure machines with wires wound into slots, but he could not see any possible difficulty about getting good insulation. The insulation of the armature he had brought to the Institution was over 2½ megohms. He might say here that, although with machines as designed at present it was quite true that space was most valuable, it was nothing like so valuable when they adopted a hole-wound dynamo. With an armature with an ordinary air space, if they increased it, they must put more ampere-turns on the magnets. But if they were going to run with a smooth-cored armature, there was nothing to prevent them from increasing the diameter of the armature. They could make deep, narrow slots, and put almost as much copper in as they liked. If they put another half-inch on to the diameter of the discs it did not increase the cost of the machine to any appreciable extent. There were a few more pounds of charcoal iron discs, but there was no other expense in proportion. He had not thought Prof. Ayrton's proposal out properly, but he thought that arrangement of putting a cell in between two brushes could not work at all, and for this reason: they could not alter the current which was flowing in the coil; they could not perform the commutation without the identical current flowing through the circuit. He thought if they worked it out they would find that, and, consequently,

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the resistance they were obliged to put in was absolutely fatal. Mr. Snell also thought he was wrong in going back to the toothed armatures; what he had said about the possibility of increasing the diameter of the armature without making a substantially bigger machine answered him to some extent. Prof. Forbes spoke of an alternating-current motor in which a somewhat similar device to his had been used. He might say he had also been on that track. Three years ago he designed a machine (which was never made) on those very lines. He feared he could not do justice to Mr. Housman's remarks, although there was a great deal that was very interesting in them. One point that Mr. Housman brought out was that that reversal of the current in the section that was being commutated was nothing like a straight line. He (Mr. Sayers) was quite aware that it was not a straight line, but he thought he would be complicating his Paper far more if he attempted to go into such details. Mr. Housman still adhered to the idea that a considerable current was generated in the short-circuited coil when passing the brush. He (the speaker) could not see how that was possible, because if the machine were running with the brushes in the proper position—he meant a sparkless position—when the coil became short-circuited there was an electromotive force being induced in it opposite in direction to the current which was flowing, consequently, instead of the current rising, as Mr. Housman represented in his diagram, it immediately began to fall. It might not fall in a straight line to the lower point, but it could not increase. It was carried through zero necessarily, and if the brush broke connection with it at the very instant when the current was at the right value in the opposite direction, there could not be any spark; the current was at zero, and the electromotive force of course was at zero as well. Mr. Housman cited as evidence the difference in speed between a generator and a motor. Now, there was a very simple explanation of this, which, so far as he knew, had not been published. If they had a shunt-wound generator to give 100 volts, then in the armature there would be $100 + C R_a$ = say 103 volts. Taking a motor with 100 volts, they had 100 volts on the shunt, exactly the same as with the generator; but they had 100 volts on the armature as well, consequently they had only got $100 - C R_a = 97$ volts. Consequently, they had there at once a difference of 6 per cent. in the speed, and when they considered that probably there was a loss of 3 per cent. in the armature, and probably another 1½ per cent. in the brush lead and surface resistance of the brush, they must see that they would probably get a difference of 10 per cent. in the speed between the generator and the motor with the same volts. With regard to reversing pole-pieces, he might remind them that Mr. Swinburne pointed out some time ago the difficulty, almost the impossibility, of designing them. With regard to Mr. Siemens's remarks, he had quite expected to hear that sort of thing said. He was not able to do what some gentlemen had asked him to do, to say distinctly what the saving would be. If they would take a license and experiment for themselves, that would be the simplest way to arrive at it. Mr. Mordey hit the nail on the head when he pointed out that what he (Mr. Sayers) had aimed at was reducing the air space.

The PRESIDENT (Mr. W. H. Preece) said it was quite refreshing to have heard in that room something novel about the dynamo. They had had Paper after Paper dealing with theory and the principles of the dynamo, but here they had something new, and which showed that, notwithstanding all the remarks that had been made, sometimes by himself, against the dynamo, the dynamo was not played out. What Mr. Sayers had shown them was that he was able to do something useful in another way, and he sincerely hoped Mr. Siemens would jump at Mr. Sayers's offer and let him have the skeleton of a dynamo in order that he might prove how the skeleton of a dynamo might be made more useful at a cheaper price, for, after all, it was a question of £. s. d. It was of no use bringing new facts before their meetings and discussing them unless they were going to be economical as well as useful. Let them hope that the offer would be the means of convincing the Institution that Mr. Sayers's method would be economical.

THE WEST COAST OF AFRICA CABLES.

On May 15th last a deputation waited upon the African Direct Telegraph Company with reference to the cost of cabling to the West Coast of Africa, and an extension of the Company's cables from Bonny to Old Calabar. The deputation consisted of Mr. W. F. Lawrence, M.P., and representatives from the Liverpool and Manchester Chambers of Commerce. The Directors present were Sir John Pender, G.C.M.G., M.P. (Chairman), the Marquis of Tweeddale, and the Hon. W. St. John Brodrick, M.P., Directors, and Mr. Thomas Fuller (the Managing Director).

Mr. W. F. LAWRENCE, M.P., introduced the deputation, who, in a printed statement, pointed out that the Company had four years ago been approached on the subject of reducing the rates for telegrams to the West Coast, and that they had then stated that the revenue from the West African traffic did not meet the working expenses, and without the subsidy of £19,000 per annum paid by Her Majesty's Government the Company could not exist; and the African Trade Section of the Liverpool Chamber of Commerce, which at that time approached the Company, forbore, under the circumstances, to press for the consideration of its views. Two years ago correspondence was re-opened with the Company, which was asked whether it was prepared to make a substantial reduction in the charges to British traders, provided Liverpool merchants and shipowners would undertake to pay in the year following such a reduction not less than the cost of their messages in the preceding year. This proposal, it was urged, had not been fairly considered by the Company. Before meeting the Company on the present occasion, a committee of the African Trade Section of the Liverpool Chamber had addressed a letter to all the members of the section (numbering 75 firms and individuals), and felt justified, from the nature of the replies received, in assuring the Company that all the principal users of the cable in Liverpool would consent to join in the guarantee referred to, in which the deputation felt assured of the support of Manchester, Glasgow, and London. In urging their views upon the Company, the deputation felt strongly that, in view of the growth of trade with West Africa, the large number of vessels employed on the coast, and the increased intercourse between the native populace with this country, any reductions granted by the Company under the guarantee proposed by the deputation would lead to an extended use of the cables, and thus result in an increased revenue. With regard to the suggested extension of either a landline or cable between Bonny and Old Calabar, Sir Claude Macdonald had furnished the Liverpool Chamber of Commerce with information as to certain details which enabled that body to recommend that a subsidy of £2,000 per annum should be paid by the Oil Rivers Protectorate to the Company in consideration of their agreeing to the extension. Old Calabar is the headquarters of the Oil Rivers Protectorate, and, in view of such an opening up as the extension of the telegraph would materially assist in bringing about, a considerable increase in trade would be reasonably anticipated.

These views were supported by, amongst others, Mr. FAIRLEY (of Manchester), who said that when the cable was established he was living as a resident in the Colony of Lagos, and could speak with knowledge of the appreciation there of the advantage of being in telegraphic communication with Great Britain. It was of immense service in many ways, and had increased commerce. But the expectation formed of increased opportunities of communicating with home firms had been much disappointed because of the high rates. They also felt sore that their French competitors were able to telegraph at much lower rates than they could. He hoped, therefore, in the interests of the Company itself, that serious consideration would be given to the grievances which the deputation had set out. It had been suggested in the statement read that a guarantee might be given with a view to protecting the Company from loss through reduction of the rates. He did not know how far that could be carried out, because all represented in the trade were not there, nor could they speak for all the interests involved, but he thought it was worth careful consideration whether such a system might not offer a solution of the whole matter. He would like to take this opportunity of saying that the native people were very fond of communicating with one another, and would do so if cheaper rates were granted. Members of the same family were distributed along the coast over a distance of perhaps 2,000 miles, and the Company would create a revenue not to be despised by cultivating traffic from this source. They did not expect the Company to work for nothing, but on the broad grounds of policy they urged a considerable reduction in the rate.

Sir JOHN PENDER, G.C.M.G., M.P. (Chairman of the Company), in reply, said: I can only assure you, gentlemen, that we are very glad to see you, and delighted to hear your views. The question that you have been broaching to-day is one that has been so often put before me that naturally I have got some little experience of what reductions in rates lead to. I may say at once that if you could persuade the Government to take a proper view of what they ought to do, I am quite prepared to deal with it. It is their duty to develop trade in every part of their Colonial possessions, and we have the same policy in regard to extensions of our system, and would be willing to make the connection you suggest if we saw that it would lead to the result you anticipate. It is the proprietors of this Company who have found the half-million of money necessary to establish this system, and unless we meet them with dividends, you may depend upon it, we do not get a cordial reception. I am quite sure, if you were standing in my place, you would not advocate any policy which you felt would not yield a moderate return upon the capital invested, and the Directors of companies, more particularly, have a double duty to be cautious because they are not dealing with their own money. Now the facts are very simple indeed. If you were to get the Government to guarantee the traffic something might be done, but when I tell you that for the first three years we paid no dividend, in 1889 2 per cent., in 1890 and 1891 4 per cent., you will see that we have no margin justifying us in incurring any risk of loss. Since we started, repairs have cost us £35,000, and another Company with which we work has spent since 1889 £25,000 in maintaining their system, so that the repairs of cable on that coast has involved the expenditure of the enormous sum of £60,000, and at the present time we have a ship making a repair just off the Congo. Now you say to me, "Reduce your rates to half and you will double your revenue." Well gentlemen, we have tried this with the Australian Colonies. We agreed if they would guarantee a certain revenue we would reduce our rates from 9s. 4d. to 4s., but after the low rate was in operation two years they came to us and begged us to somewhat increase our rate, because the loss was too heavy for them to bear. In the case of an enterprising people like the Australians, we have full confidence that the result will eventually justify the experiment, but I have never known the black races do much for submarine telegraphy. They have not done so either in the West Indies or anywhere else. The interests which you represent are, telegraphically, comparatively small. Liverpool only contributes about 15 per cent. of our income, small as it is, and Manchester figures for only a small proportion also. Let me tell you also, that but for two factors this Company would not have been able to exist. The first is the guarantee from the Government, and we accept all the responsibility which Mr. McArthur has alluded to, because if we saw any way in which we could develop traffic we should be the very first to encourage it. The guarantee proposal is not business because it would be an individual one, and would, therefore, not be a workable guarantee at all. I should require to ask who is to guarantee the guarantors. But if you will go to the Government and get such a guarantee as will enable us to earn a fair—not extravagant—dividend, we (the Company) will take some portion of the risk, believing that there is a development to work for. Germany came to us very much as you have done, but they gave us £6,700 per annum towards a cable. The reduction of rates to the Australian Colonies had resulted in a large increase, but not enough to recoup us for the loss made by the reduction

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of the rate. You have made a strong point about the difference of rates as compared with the Portuguese and French colonies, but it is the Governments which are bearing the loss in connection with these low rates. I may explain to you that there are two *régimes* established by the International Telegraph Convention, namely, the European and the extra-European. The first applies primarily to the whole of Europe, and affects our system wherever we are in competition with European land systems. The African Direct Company works under the extra-European *régime*, but France and Portugal have chosen to regard their West African cables as forming part of the European *régime*, and consequently their rates are lower than ours; but Governments have got long purses, and can do what it is not in the power of a company to do. I do not say that Portugal has got a very long purse, but at any rate she does very bold things in telegraphy, and if a loss occurs it falls upon the Government, whereas in our case it would fall upon our shareholders. I therefore put it to you, gentlemen: How could we agree to a reduction when we pay our shareholders such an insignificant dividend? We are not in a position to lay by any reserve, and we find the waters in which our cables are laid are not by any means favourable for maintenance. I do not see myself that the position of the West African cables is at all encouraging, and I am sorry I cannot hold out any hope to you of the rates being reduced at present. I must again turn your attention to the Government, who have got power and can afford to do it. The subsidies from France and Portugal amount together to £39,208, whilst that from Great Britain is only £19,000. I should mention also, that by making our line part of an alternative route to the Cape we have secured an addition to our revenue, without which we should have been in a much worse position. I do not see the amount of telegraphy in your African trade which would warrant us in making the changes you suggest.

With regard to the extension of the cable from Bonny to Old Calabar, I think if you were to get the Government to give a subsidy of £2,000, in addition to what Sir Claud Macdonald offers, something might be done. Very often if the locality will do something towards such an object, the Government will do something too. If we were to make the reductions you suggest, it would affect the whole of our system. No merchant trading to India or China but would come to us and say: "You are taking such and such a rate to West African ports, and we do not see why you should not reduce the Indian and Chinese rates also." The merchants there are just as sharp as elsewhere, and we get letters frequently asking us to consider seriously whether we cannot meet their wishes, but we have to consider all these things as a whole. There is another very important point, and that is that if the messages were of the same average length as they were in the early days of submarine telegraphy we should be doing very well indeed, but there is not one of you gentlemen who has not adopted a code system, and you will admit that it does not in reality cost you anything like the charge per word we are making. With the elaborate codes you use, the charge per word is more like 9d. than 9s.

Mr. TUNNICLIFFE (of Liverpool) said his firm paid the Company £1,414 for telegrams during the year 1891-1892, and had paid since then for the half-year £687. Sir John had referred to the question of coding, but his Association found that frequently it would be a great deal better to send the whole of the message in clear language. Supposing the Company had a substantial guarantee in respect of a reduction to the Oil Rivers they would get more than they now received. In the event of an extension to Old Calabar he thought there would be a still greater increase. While the African Direct Company's rate to Lagos was 8s. 10d., the French Company's charge was only 6s. 3d. He would, therefore, ask if the Company could not put the Lagos merchants on the same terms as the French Company would do by transmission from Porto Novo, or otherwise, as a matter of economy, they would be compelled to resort to the latter route.

Sir JOHN PENDER: If you will get our Government to do for our trade what the French and Portuguese Governments do for theirs, and submit some scheme of guarantee of a practical nature which we can consider, we will do everything in our power to meet you.

Mr. LAWRENCE thanked the Chairman very cordially for the way in which he had received them. No doubt, some were disappointed that they had not received more encouragement, but they trusted time would show that they were right.

The deputation then withdrew.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 19, 1893.

Electric Railway Building.—The building of electric railways has developed into a craze with us, and new projects are put on foot almost by scores daily. The prevalent topic nowadays is of "networks," and every ambitious town endeavours to become a radiating centre for roads leading into the rural districts, connecting the smaller towns with it. Many companies have also been formed for more ambitious undertakings, such as roads a hundred miles or more in length. As a consequence of this, the two great electric railway manufacturing companies are overloaded with orders; the General Electric Company reports unfilled orders for 2,500 railway motors and 127 railway generators, and the Westinghouse Company states that the orders it has on hand, with those received since April 1st, amount to $3,028,000, which is about double the figures for the same date last year.

The American Institute of Electrical Engineers.—This Institute held its annual meeting and election on May 16th and 17th, at which Prof. Edwin J. Houston was elected president for the ensuing year. Seven Papers were read, of which Prof. Carpenter's, "On the Variation in Economy of the Steam-Engine due to Variation in Load," and Prof. Pupin's, "On Practical Aspects of Electrical Resonance," were the most important. Prof. Carpenter developed formulæ, by means of which, if the usual data of a steam-engine at normal power is known, the water consumption, when run below the normal, may be determined. The Paper of Prof. Pupin was read in his laboratory at Columbia College, and was illustrated with many interesting experiments; among other things, the Professor illustrated the effect of capacity on alternating currents, increasing the electromotive force from 80 volts to above 1,000. The Professor also illustrated his method of harmonic selection; by means of a telephone and tuning-fork the adjustment of his apparatus could be so made that a wave of a definite periodicity could be easily selected.

The Westinghouse and General Electric Companies.—The sensational charges made against the General Electric Company by the Westinghouse Company have received no new developments. The General Electric Company was accused of having spies in the works of the Westinghouse Company for the purpose of stealing the plans, proposals, &c., of the latter, thus placing the latter Company at a great disadvantage in competition. A legal search of the premises of the General Electric Company was made, and a number of alleged stolen plans recovered, and the entire matter is now in the hands of the legal authorities.

The Electric Displays on the British Warships.—During their stay in New York the British warships greatly enhanced the prestige of the British Navy with the public by their brilliant electric-light displays. Although an attempt in this direction was made by all the vessels, including American, the British ships overshadowed all others to such an extent as to excite general comment.

CORRESPONDENCE.

COOKING AND HEATING BY ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The error in my letter published in *The Electrician* of May 19th, stating "one quart" instead of "one pint," is so palpable that every engineer must have known what was meant. The heat units generated by the current mentioned at 100 volts, would boil about 1 3lb. of water at 60°F. in ten minutes, but allowing for loss of heat, one pint could easily be boiled in this time. I do not, however, consider that the ordinary forms of kettles, saucepans, &c., are the most suitable for electrical heating; even the gas engineers have accustomed us to large flat-bottomed apparatus not previously employed. I am now making a new type of boiling arrangement specially suitable for use with electric heaters, which will, I believe, be a great advance on all others. It is interesting to hear from so eminent an authority as Mr. Thomas Fletcher that coal cannot be compared with electricity. This is exactly my opinion. Just as gas, when used for boiling purposes, affords many advantages over coal, so electricity will outstrip its rival for heating, as it is now doing for lighting.

It is not my intention to enter into a long controversy upon the merits of electricity in its latest phase, for this is unnecessary. The inquiries and orders we have in hand are sufficient proof of the public interest in this new departure. It is a mistake to consider that the expenditure of a few pence extra in cooking a dinner will deter those who have electricity available from using electrical cooking apparatus, particularly when it can be shown that the food is cooked in an absolutely pure atmosphere and in the most perfect manner. There is no

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doubt that the old adage of "the proof of the pudding is in the eating" comes in with greater force in the present instance than is often the case.

Full particulars of trials will be published shortly, and I prefer to let these speak for themselves rather than discuss the theoretical possibilities of using electricity in this direction. The cost of using the apparatus is, of course, an important item; but I am satisfied that wherever the current is sold at a reduced price during the daytime, when most cooking operations are carried out, it can be used in competition with many other forms of apparatus now employed.

I remember, some ten or twelve years ago, that we were treated to long articles in journals interested in gas supply, *proving conclusively* (so they said) that electricity could never be supplied at a price that would be cheap enough to bring it into use for lighting purposes. The same thing is now happening with regard to the use of electricity for cooking and heating; but, as current is not only available, but in extensive use at the present time, I have no fear that as soon as the advantages of the electrical cooking and heating apparatus are known, electricity will be used for these purposes also.—Yours, &c.,

H. J. DOWSING.

London, E.C., May 31, 1893.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I certainly did not intend to use hard words about Mr. Dowsing's communication. I took his figures, and gave the comparative cost on his basis, which, it appears, is not correct. I do not profess to be an expert in electricity. It is not necessary to obtain the "specific heat of a mutton chop." This will be for practical purposes identical with that of water, of which it is largely composed. The actual heat used in cooking a mutton chop can be calculated with the greatest ease by weighing before and after cooking, and calculating the heat expended on evaporating the water, as almost all the work is expended on evaporating the necessary part of the water from the meat. Those who are attempting to make electrical cooking popular, must not forget that in this country, at least, stewing and cooking in close vessels, covered with non-conductors, is by no means popular, although useful to a limited extent for certain classes of work. Mr. Binswanger states that he is making an apparatus which will "cook" a small leg of mutton and about 5lb. of potatoes and cabbage with an expenditure of about two-thirds of a unit, say, 3d. In Dr. Kinnear Clark's report to the Committee of the Gas Institute (*see* Vol. I., p. 128) a test was made by roasting in an open chamber, by *radiant* heat, 7lb. 7½oz. of mutton, grilling two soles (1lb. 14oz.), roasting 5lb. of potatoes, and baking a rice pudding, a rhubarb tart, and some puff pastry, the gas consumed being 24·9 cubic feet, and the cost less than one penny. I should not have entered into the correspondence but for the fact that the duty of other fuels than electricity was being misrepresented, and I simply furnished the figures for calculation to prevent future errors. The quality of electrical cooking will no doubt be fairly judged on its own merits; the cost in many cases is not important, but if the question of cost is brought forward it should be done so fairly and from proper data which can be verified.—Yours, &c.,

Warrington. THOS. FLETCHER.

SUSPENSION WHEELS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your announcement of the death of Mr. E. A. Cowper, whose loss we all very much regret, you mention that the invention of tension wheels for bicycles in 1868 is attributed to him. Without detracting in the least from the importance and value of the late Mr. Cowper's numerous and useful inventions, I wish to mention that tension wheels were made between 1840 and 1850 by William Worby, at Ipswich, the inventor of numerous machines and implements of great practical success. In 1867 he gave me a pair of what he called his suspension wheels for a tricycle I was then about to make.—Yours, &c.,

W. WORBY BEAUMONT.

London, May 29, 1893.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1893 Edition of "THE ELECTRICIAN" Electrical Trades Directory and Handbook is NOW READY. This useful book contains over 1,000 pages, and several new and handy features have been added. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

TENDERS INVITED.—The Urban Sanitary Authority of the Borough of Portsmouth invite tenders for the supply and erection of electric cables (both high and low tension), conduits, feeding boxes, &c. Copies of the specification, plan, &c., can be obtained of Mr. Alexander Hellard, Town Clerk, at the Town Hall, Portsmouth, on and after the 5th inst., and other information can be obtained of Messrs. Kincaid, Waller and Manville, 29, Great George-street, Westminster. Tenders must be in by 10 a.m. on Friday, the 23rd inst.

——— The Mayor, Aldermen, and Burgesses of the Borough of Harrogate invite proposals from persons or companies willing to undertake the duties and responsibilities of the Harrogate Electric Lighting Order, 1891. Further particulars are given in our advertising columns, and a schedule of terms and conditions can be obtained of the Borough Surveyor. Proposals must be sent in to the Chairman of the Electric Lighting Committee not later than noon on Thursday, 15th inst. Mr. George Wilkinson, M.I.E.E., is consulting electrical engineer.

——— The Electric Lighting Committee of the Halifax Corporation invite tenders for the supply and laying of a system of underground mains, pipes, manholes, &c. Some particulars are given in our advertisement columns, and forms of tender and all other information can be obtained of Mr. T. P. Wilmshurst, A.I.E.E., borough electrical engineer. Tenders must be sent in to Mr. Keighley Walton, Town Clerk, Town Hall, Halifax, not later than July 1st next.

——— The Caledonian Railway Company invite tenders for stores for twelve months from August 1st next, including telegraph and electric appliances, iron wire and strand, indiarubber, lamps, and lamp furnishings, tools, timepieces, gas and water fittings, bolts and nuts, rivets, &c., &c. The list is set out in our advertisement columns, and specifications and forms of tender and all further information may be obtained after the 5th inst. from Mr. J. Lorimer, superintendent of stores, Caledonian Railway, Charles-street, St. Rollox, Glasgow. Tenders must be sent in to Mr. J. Blackburn, secretary, 302, Buchanan-street, Glasgow, not later than Monday, the 19th inst.

——— The Corporation of Cardiff invite tenders for boilers, engines, machinery, and electrical apparatus. Tenders must be in by Monday, the 19th inst.

——— The Directors of the North-Eastern Railway require tenders for the supply of telegraph apparatus and telegraph wire and line stores during the six months July-December, which tenders must be in by the 6th inst.

——— *Public Lighting.*—The Corporations of Great Grimsby and Norwich and the Local Board of Bishop's Stortford invite tenders for the public lighting of their districts. No reference is made in advertisements as to whether electric light, gas, or oil will be adopted. Tenders must be sent in by June 9th, 10th, and 17th respectively.

TENDERS ACCEPTED.—The Building Committee of the Free Library and Museums Committee of the Carlisle Town Council have accepted the tender of Messrs. Latimer Clark, Muirhead, and Co. (Limited), London, for the work in connection with the installation of the electric light at Tullie House, for the sum of £1,450. This tender does not include the foundation, masonery and joinery work, but includes gas engines and the provision of duplicate plant. The accepted tender was the lowest of more than 20 sent in.

——— The Edinburgh Town Council have accepted the tender of Messrs. McCulloch, Sons, and Kennedy for the electric light installation at the Powderhall Refuse Disposal Works, for the sum of £354. 18s. 1d.

——— The tender of Callender's Bitumen, Telegraph, and Waterproof Company (Limited) has been accepted by the Hull Town Council for the necessary work in excavating for the extension of the electric light through various thoroughfares in the Council's district at £1. 19s. 6½d. per yard.

BANKRUPTCY.—The receiving order in the estate of Mr. C. J. Allport, electrical engineer, of 24, Woburn-place, Russell-square, has been discharged, the debtor having agreed to pay 20s. in the £ within a fortnight of approval by the Court.

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APPOINTMENTS VACANT.—Particulars are given in our advertisement columns of several vacant appointments in the Indian Telegraph Service.

REMOVAL NOTICES.—The United Electric Light Company, agents for the Watt arc lamp, have removed their offices to 5, Featherstone-buildings, Holborn, W.C.——The Machinery Purchase Hire Company is removing from 147 to 46, Queen Victoria-street, London, E.C.

APPOINTMENT.—Mr. W. J. Corse, electrician, of Old Town-street, Plymouth, has been by Royal Warrant appointed Electrical Engineer to the Duke of Edinburgh.

PATENTS FOR SALE.—Messrs. Danger and Neville, of 41, North John-street, Liverpool, have for disposal the British Patent, No. 17,740, 1890, for rainbow letters and electrical advertising devices.

——— Messrs. James A. Brown and Co, of Chesterfield House, Great Tower-street, E.C., have for disposal patent rights in Great Britain, by which it is claimed that incandescent lamps can be repaired or supplied to consumers at 1s. each, net.

ELECTRICAL TRADES' UNION.—At the Conference of this body, held at Newcastle, a discussion took place on the subject of admitting electrical appliance makers to the Union, and it was decided to admit this branch. The Conference rejected the proposal for adopting the apprenticeship system for electric light wiremen. It was further agreed, on the question of the admission of females to membership, that they should be organised as electrical operators. Mr. A. J. Walker was re-elected as general secretary, and Mr. A. B. Johnson as organiser. Mr. W. T. Gooday was elected President, and Mr. A. Senior Vice-President, of the next Conference, which is to be held at Birmingham.

COLLIERY PLANT.—The Shillbottle Colliery Company have decided on putting down an electrical pumping plant for their colliery capable of delivering 200 gallons of water per minute against a head of 185ft. Messrs. Ernest Scott and Mountain (Limited) have secured the contract for this work, and also for a coal-cutting plant for a firm of coalmasters in Scotland.

EDISON AND SWAN COMPANY.—We have received a copy of the latest edition of the price-list issued by this Company. The new list is Section 5, and deals with brackets, standards, electroliers and fancy shades. The list is full of illustrations of a very large variety of fittings, many of which are of elegant design, a remark which particularly applies to the brackets illustrated on pages 10, 11 and 12, and to a number of the electroliers shown in the list.

MESSRS. JOHN H. HACKWORTH AND CO.—We are asked to state that this firm have acquired the business of the Machinery and Hardware Company (Limited), of Queen Victoria-street, and that they will in future carry on the business at 46, Queen Victoria-street, E.C.

THE GENERAL ELECTRIC COMPANY'S CATALOGUE.—This very elaborate catalogue consists of some 400 quarto pages, and we are informed that it contains over 10,000 illustrations and 50,000 prices. It consists of six divisions, which deal with (1) electrical supplies and wiremen's sundries, (2) electrical plant and machinery, (3) electrical fixtures and glassware, (4) electric bells and accessories, (5), telephones and accessories, and (6) electro-medical apparatus. One of the features of this catalogue is the great variety of the minor accessories which are fully illustrated. A large portion of the goods described are made by the General Electric Company, but, of course, there are many articles, such as engines, dynamos, glassware, &c., for which they act as merchants. Not only have the names of the makers and other designations been carefully omitted, the "Hedgehog" transformer, for example, appearing as an "open-circuit" transformer, and the Willans engine as "closed type engine," but the General Electric Company have suppressed their own name in the body of the catalogue, enabling the trade to use it as a book of reference for their customers. To many of the well-known specialities of this Company it is unnecessary to allude. A large variety of switches are described, and the excellent H. I. cut-outs and ceiling roses, with a porcelain partition between the wires. The General Electric Company are erecting a large factory for the production of glow lamps as soon as the patent expires, and promise "Stella" lamps of 3 watts per candle, or even 2½ watts per candle with a somewhat shortened life. Among the testing instruments we notice that a few Evershed ohmmeters are kept in stock in London for letting out on hire, a great convenience to those who do not often require these instruments. A page of sample wiring estimates is given, but it is a pity that such low figures should have been quoted. They may be based on good work, but in the large majority of cases they would only tempt contractors to make a profit out of extras, for the estimates for labour seem quite inadequate. A very large variety of stoneware insulators are given, and a good selection of insulator fittings. Among other novelties we notice that a "tubular system of wiring," recently described in our columns, is offered; this consists of *papier maché* tubes impregnated with bitumen. These may be let into plaster, but leave the wires accessible, the bends and elbows being well rounded. Among the accessory fittings for electric light we notice some neat cord-shorteners and insulating flanges for insulating gas fittings. The fittings of the General Electric Company are all provided, unless specially ordered, with ½in. tubes, allowing room for good insulation, and 26 threads to the inch are always used. In this and other matters great care has been taken to standardise appliances so that interchangeability is secured. This catalogue should form a useful price-book for electrical engineers, contractors, and exporters.

ABERDEEN.—The Town Council, at their last meeting, discussed the question of the electric light, and, amongst other matters, decided to appoint an electrical engineer to take charge of the electric lighting department, at a salary of £200 per annum. Further particulars will, we understand, be shortly announced.——The Northern Co-operative Company have received Porf. Kennedy's report on the proposed electric lighting of their extensive premises in Loch-street and Gallowgate. The initial outlay is estimated at about £1,400, and the annual cost at £270—a saving of £50 annually on the cost of gas. After discussing the report for some time, the Directors adjourned its consideration to a future meeting.

BOLTON.—The Corporation have, we understand, selected a site in the vicinity of Spa-road for the electric-lighting station, and progress is to be immediately made with the erection of the works, for which elaborate plans and particulars have been prepared by the borough electrical engineer, and are under the consideration of the Electric Lighting Sub-Committee. The system to be adopted has not yet been finally settled.

EXETER.—The Devon Standing Joint Committee have decided to light Exeter Castle by electricity, the installation to include the new offices, at a cost not exceeding £135. 11s.

GLASGOW.—The District Lunacy Board have further discussed the subject of introducing the electric light into the various buildings connected with the Gartlock Asylum, and have deferred their decision until certain matters in connection with the site for some buildings has been agreed upon.

HULL.—The success of the electric light in Hull is fully assured, and a considerable extension of the original area is now being proceeded with. The Town Council, at its last meeting, received an order from the Hull branch of the Bank of England for a large installation at the bank's premises.

LEEDS.—The new building in course of erection for the Medical Department of the Yorkshire College, at Leeds, is to be lighted entirely by electricity. The installation is to consist of about 750 lamps, the contract for which has been secured by Mr. T. Harding Churton.

LIVERPOOL.—The annual meeting of the proprietors of the Liverpool Library in Bold-street has been held, and the Directors stated that the electric light has been introduced at a cost of between £80 and £90, and that the Committee of the Library believe that this expense will be more than recouped in a very brief period by the saving in book-binding alone, which for the past year amounts to about £120. The report continues "it has been a source of regret to successive Committees to find that bindings of a large number of books have become seriously injured by the gas. The change to electric lighting has induced the Committee to have a number of the most important books rebound in a superior style." Other Library Committees please copy.

LLANGOLLEN.—At the last meeting of the Local Board a Committee was appointed to consider the question of supplying electric light to the town. It is proposed to use water-power, and if the scheme proposed by Mr. Brayne, of Liverpool, is adopted, the water-power plant will be erected on the River Dee, immediately above the Llangollen Flour Mill. The water-power plant is estimated to cost about £800, and the complete scheme about a further £1,600.

PENYMYNYDD.—A new electric organ has been erected in the church of St. John, and at a recent trial of the instrument, at which Mr. Gladstone assisted, great satisfaction was expressed.

NEWARK.—An application has been made by the promoters of a scheme for the electric lighting of this borough to the Urban Sanitary Authority asking their consent to the promoters obtaining a Provisional Order to enable them to carry out the scheme. The matter was referred to the Lighting Committee.

NORWICH.—At the last Town Council meeting a discussion arose as to the renewal of the Gas Company's tender for lighting the public lamps, and a member of the Council hoped that before next year some arrangement would be entered into with the Local

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Electric Lighting Company for the lighting of the principal streets by electricity. On behalf of the Gas Committee, Mr. White stated that before the new contract with the Gas Company expires efforts would be made to complete arrangements with the Electric Lighting Company in the direction referred to.

OSTEND.—It is stated that the municipal authorities contemplate inviting tenders for the electric lighting of the city.

RUGBY.—A proposal to light Rugby School by electricity has been before the governors for some time past, but has not, we understand, met with complete approval. It is now being energetically promoted, and the question will be definitely settled shortly.

SOUTHPORT.—A special meeting of the Town Council was held on Tuesday last to consider the question of adopting an electric lighting scheme for the town.

TIVERTON.—The Town Council had under discussion on Wednesday a report of the Electric Lighting Committee, who recommended the adoption of a scheme which, while costing £13,700, would not, in the Committee's opinion, be any additional burden on the rates. It was ultimately decided, however, that the scheme be postponed for a twelve-month.

WORCESTER.—The Guardians having negatived the proposal to instal the electric light in the workhouse building, a deputation from the Town Council has been appointed to wait on that body to prevail upon them to adopt the electric light, and the Guardians propose to find accommodation for an engine and dynamo capable of supplying the necessary number of lights, pending the completion of the Council's suggested electric lighting scheme. The Council propose to arrange with the Brush Company to supply the plant at an estimated cost of £200. At the last meeting of the Board of Guardians the matter was not finally decided, and the deputation appointed by the Council will probably succeed in their mission.

BOOKS RECEIVED.

"Edison Feeder Patent." Full text of judgment delivered April 10, 1893, in case, Edison Electric Light Company *v.* Westinghouse Company. (New York: General Electric Company.)

"Story of the Atlantic Telegraph." By Henry M. Field. (London: Gay and Bird.) Price 7s. 6d.

PATENT RECORD

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

May 13, 1893.

9,638. E. J. HALL. London. Central office apparatus and circuits for telephone changes. [Date applied for under Patents Act, 1883, Sec. 103, October 13, 1892, being date of application in United States.]

9,639. E. J. HALL. London. Trunk-line signalling apparatus and circuit for telephone exchanges. [Date applied for under Patents Act, 1883, sec. 103, October 13, 1892, being date of application in United States.]

9,640. E. J. HALL and F. A. PICKERNELL. London. Electrical signalling apparatus and circuits. [Date applied for under Patents Act, 1883, Sec. 103, October 13, 1892, being date of application in United States].

9,641. E. J. HALL and F. A. PICKERNELL. London. Busy signals for telephone circuits. [Date applied for under Patents Act, 1883, Sec. 103, October 13, 1892, being date of application in United States.]

May 15, 1893.

9,662. J. E. B. WALKER. Birmingham. An electric lamp for bicycles, tricycles, and all kinds of rolling stock.

9,664. CH. MELLIER and Co. (Godfrey, Dinlacher, and B. A. Lacoste.) London. Improved plug for combination electric candle fitting.

9,670. S. D. WILLIAMS, W. J. CLAPP, and G. H. LLEWELLYN. Newport, Mon. An electro-chemical purifying process in iron making and for other purposes.

9,699. W. GORDON. London. Improvements in connection with connecting joints for electric mains, telegraph wires, and telephones.

9,716. W. DEFRIES and V. J. FEENY. London. An improved method and apparatus for the production of electrical effects in ballets and other theatrical representations.

May 16, 1893.

9,753. W. E. AYRTON and T. MATHER. London. Improvements in electrical and other measuring instruments and apparatus.

9,779. C. A. ALLISON. London. Circuit switch. (The Electrical Speciality Company, United States.)*

9,780. F. V. WOOD. London. Improved electrical apparatus for obtaining light.

9,805. SIEMENS BROS. and Co. (LIMITED) and F. JACOB. London. Improvements in contacts for making and breaking electrical circuits.

9,810. H. C. BULL. London. Improvements in, or connected with, incandescent electric lamps.

9,818. J. F. CUMMINGS. London. Improvements in underground conduits for electrical conductors.*

9,819. W. P. HALL. London. Improvements in electric circuit controlling devices.*

9,821. H. H. LAKE. London. Improvements in galvanometers (Whitney Electrical Instrument Company, United States.)*

May 17, 1893.

9,864. R. G. EVERED and A. WATSON. London. Improvements in electrical switches.

9,906. D. G. FITZGERALD. London. Improvements in the manufacture of elements or electrodes for voltaic batteries and electrolytic decomposition cells.

May 18, 1893.

9,965. A. LONGSDON. London. Improvements in or connected with the working and welding of metals by electricity. (The firm of Fried Krupp, Germany.)*

9,997. S. COPETER and H. NEHMER. London. Improved method of generating electricity direct from heat.

May 19, 1893.

10,006. H. W. SWAIN. Runcorn. Fine art electro-plate.

10,015. R. E. B. CROMPTON and H. J. DOWSING. London. Improvements in apparatus for use in the utilisation of electrical energy for culinary purposes.

10,042. F. KING. London. Improvements in and apparatus for the manufacture of plates, grids or supports for secondary batteries.

10,043. H. W. BUDDICOM. London. A current governor for electromotors.

10,056. C. OLIVETTI. London. An improvement in commutators for electric machines.

May 20, 1893.

10,091. W. GREENHALGH. Leeds. Improvements in and relating to electromotors.

10,095. E. DE PASS. London. Improvements in electro-plating. (Hermann Thofehrn, France.)

10,107. J. H. KINSMAN. London. An improved telephone call.

10,129. H. EDMUNDS. London. Improved electrical conductor.

10,130. H. PIEPER. London. Improvements in means for supplying current for driving vehicles on electric railways or tramways.

10,131. W. B. SAYERS, H. A. MAYOR, W. A. COULSON and S. MAYOR. London. Improvements in the construction of armatures for dynamo electric machines.

10,142. W. FRITSCHE. London. Improvements in and relating to electric machines.

May 23, 1893.

10,147. F. DOWLING. London. Electric belts, corsets, and appliances.

10,205. F. L. and L. H. DYER. Electric steering gear.

10,207. A. C. SEIBOLD. London. Improvements in electrodes for arc lamps.

10,218. R. WOOD. London. Improvements in methods of regulating the distribution of electricity, and in converting its energy into that of light.

May 24, 1893.

10,242. C. ADAMS RANDALL. London. Improvements in telephonic apparatus.

10,283. J. E. HOFMAN. Liverpool. Improvements in and connected with the manufacture of electrode plates for secondary batteries.*

10,293. W. B. SAYERS. London. Improvements in dynamo electric machines.

10,304. J. LOBLEY. London. Improvements in lighting and extinguishing electric lamps for street lighting.

May 25, 1893.

10,336. C. L. ANDERS and W. KOTTGEN. London. Improvements in microphonic contacts.

10,347. H. K. SPANGENBERG. London. Improvements in or connected with battery switches.*

May 26, 1893.

10,363. F. T. SCHMIDT. Bradford. Improvements in electrically controlled arc lamps.

10,382. T. E. CARMICHAEL. An improved switch for electric appliances.

10,396. W. L. DUDGEON. London. Improvements relating to electric conductors. (La Société Anonyme: Cockerill, Belgium.)

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10,398. G. C. L. LENNOX. London. Improvements in effecting electrical communication with vessels or buoys at sea.

10,399. D. G. FITZGERALD, E. J. CLUBBE, and A. W. SOUTHEY. London. An improved frame or holder for the plates of active material used in secondary batteries.

10,400. D. G. FITZGERALD and E. J. CLUBBE. An improved portable battery case and safety device.

May 27, 1893.

10,441. E. T. HUGHES. London. Conduit electric railway. (William R. de Voe, United States.)

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1892.

7,855. CHALLIS. Electric switches.

8,222. RECHNIEWSKI. Dynamo-electric machines.

8,745. DRAKE and GORHAM. Electric switches.

9,450 WOODHOUSE AND RAWSON UNITED, LIMITED (Varley). Electric bells.

9,569. SHREWSBURY and DOBELL. Electric batteries.

9,799. FITZGERALD. Electrolysis of alkaline chlorides.

10,022. GRIST. Electro-telephonic apparatus.

10,059. PAYNE. Electric conductors.

10,265. AYRTON and MATHER. Electrical measuring instruments.

10,738. EDISON and SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED) and GIMINGHAM. Electric safety lamps and batteries.

10,161. EVERSHED. Telegraphic communication with lightships.

10,472. EWING. Apparatus for electrical, &c., measurements.

11,085. WOODHOUSE and RAWSON UNITED (LIMITED). (Varley.) Electrical indicators.

11,382. NIEWERTH. Making chemical products by electricity.

11,487. JEFFRIES. Telephone, &c., poles.

11,532. BORSE. Storage batteries.

12,731. SIEMENS BROS. and Co. (LIMITED) (Siemens and Halske). Electrolytic extraction of zinc.

13,090. HEDGES. Incandescent electric lamp fittings.

22,838. DAY (Haynes). Telephonic apparatus.

1893.

449. STOREY. Electric motors.

1,229. LLOYD. Secondary batteries.

1,449. FOWLER. Electrical hose signalling apparatus.

2,672. BRADLEY and Others. Electric transmission of power.

4,818. DORMAN and SMITH. Electric switches, &c.

6,073. GWYNNE and KENNEDY. Arc electric lamps.

6,295. STOBER. Electric incandescent lamps.

6,031. MILLS (Courtenay). Transmitting electric currents.

6,478. THOMSON. Dynamo-electric machines, &c.

6,565. SIEMENS BROTHERS and Co. (LIMITED) and OBACH. Dry voltaic cells.

6,579. MITCHELL. Electrically heated radiator.

COMPANIES' MEETINGS AND REPORTS.

Reuter's Telegram Company (Limited).

The twenty-ninth ordinary general meeting of the shareholders in this Company took place on Wednesday at the offices, Old Jewry, under the presidency of the Hon. Mark F. Napier, M.P., in the absence, through indisposition, of the Chairman of the Company, Admiral the Right Hon. Sir J. C. D. Hay, Bart., K.C.B.

The SECRETARY (Mr. W. F. Bradshaw) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN said: I have now to move the adoption of the report. I am sure you will all agree with me that it is a source of considerable satisfaction that the result of the Company's operations last year is so much more favourable than in 1891. The increase shown under the head of subscriptions, commissions, &c., affords, we think, the best proof of the sound state of the Company's business. On the other hand, the expenditure for telegrams and agencies shows an increase which it has not been possible to avoid, as, although peace was preserved, last year was throughout a period of anxiety and public excitement. We have little to report on this occasion in regard to the advertisement branch beyond saying that in the financial depression which prevailed last year it was impossible to make very great headway. Everything is, however, in readiness for an improved state of business, and agencies have been established, which will, we are confident, yield a good return in the future. Before concluding, I should like to say a few words in support of the resolution which will be moved in regard to the question of superannuation for the staff. Although an officers' life insurance and superannuation fund has been established since 1881, no measures have yet been taken to provide superannuation allowances to the staff. The scheme which has been drawn up provides that the staff shall contribute 2½ per cent. of their salaries to a fund to which the Company will contribute a like amount. As, however, the scheme, which is open for the shareholders' inspection, explains the matter in detail, I would only say that the proposal commands our hearty support, as we can conceive of no more efficacious method of attracting to, and retaining in, the service of the Company the class of men we want in our business than by assisting them to make provision for old age.

Mr. FREDERICK J. GRIFFITHS seconded the motion, which was at once unanimously adopted.

The CHAIRMAN then proposed a resolution authorising the Directors to affix the seal of the Company to an indenture, a draft of which had been already prepared, for adopting and giving effect to the superannuation scheme referred to. He stated that the Directors had no pecuniary interest in the proposal, and they had worked out the scheme solely with the view of making the provision in question for their officers.

Mr. GRIFFITHS seconded the motion.

In answer to Mr. LIDDON,

The CHAIRMAN stated that the Managing Director had just informed him that the amount paid by the Company under the scheme would be about £400 a year. A company of their standing was often called upon to make some allowance to old members of the staff, but the scheme now proposed would put an end to this.

The resolution was unanimously agreed to.

On the motion of Baron DE REUTER, seconded by Baron GEORGE DE REUTER, Mr. Griffiths was re-elected to his seat at the Board, and the auditors, Messrs. Welton, Jones and Co., were afterwards re-appointed.

Mr. LOVEDAY then proposed, and Mr. LIDDON seconded, a vote of thanks to the Chairman and Directors, and the motion was unanimously adopted.

The CHAIRMAN, in acknowledging the compliment, said that the Directors were doing all in their power, not only to maintain the Company on its present solid footing, but, if possible, to improve and strengthen it.

The meeting then separated.

Telephone Company of Ireland (Limited).

The fourteenth ordinary general meeting of this Company was held in Dublin on Saturday, Alderman V. B. Dillon (Chairman) presiding.

The CHAIRMAN said the meeting had been called to transact the ordinary business of the Company, and also to consider a special resolution agreeing to transfer their undertaking to the National Telephone Company. Before they proceeded to dispose of the ordinary business of the meeting he would say a few words in explanation of their position. It might seem strange that while the Company was in a prosperous condition, their earnings last year being £6,000 of net revenue—a sum sufficient to pay a substantial dividend on the capital—that the Directors should recommend the sale of the property. He trusted he would be able to show to the shareholders that they would be acting wisely in adopting the special resolution. They would remember that the ordinary capital was £200,000, divided into £25,000 preference and £175,000 ordinary shares. No money had been paid in respect of the ordinary shares, the preference shareholders receiving one ordinary share for each preference share, and one-half of the ordinary shares was allotted to the National Telephone Company. In 1883 this Company required further capital, and they issued more preference shares, making the 6 per cent. preference into 5 per cent., the preference capital being thus increased to £44,749. In 1889, when all the capital was exhausted, the Directors sought to obtain further capital, and decided to issue further preference shares, but only £14,000 was taken up. Debentures were also offered to the shareholders, but only £2,900 was taken up. He thought this justified the Directors in coming to the conclusion that the shareholders were not prepared to find any further capital. The Company had opened up business in Cork, Limerick, Dundalk, and Drogheda, and had laid part of the trunk line between Dublin and Belfast; and they had also entered into negotiations for an extension to Waterford, but capital was wanted for that. In the meantime they also required to make a considerable outlay in the switch room and to provide plant, and this meant additional capital outlay. For their day-to-day extension they had been obliged to appropriate the dividend which would ordinarily have been paid to the shareholders. That had enabled them to continue their operations without extending them for two or three years. But it was manifest to the Directors that they could not go on to properly develop the system without a large outlay, and that outlay, it was plain, could not be provided by the shareholders. They had been, therefore, driven to consider some course for raising further capital. They considered whether it would be more advantageous to purchase the property of the National Company in Ulster. He should say that their Company controlled the whole of Ireland except Ulster, and if they purchased the Ulster property they would have had to form a larger company, and raise further capital. The alternative was their selling their property to the National Telephone Company, who had acquired all the telephone property in Great Britain and Ireland, with the exception of that owned by the Telephone Company of Ireland. They had, therefore, entered into negotiations with the Directors of the National Company, and they had now concluded with them an arrangement which they considered fair and reasonable, having regard to the fact that the shareholders were not willing to provide further capital. It was rather fortunate when they were discussing matters with the National Company that they had in hand a substantial cash balance which they had retained, because it had enabled them to say "If you don't give us our price we will endeavour to go on for some time longer." The agreement provided that the management would still be left under the control of a local board, which for a period of five years would consist of the present Directors of the Company. He mentioned that because it was important that local control should should be preserved over the Company. He concluded by moving the adoption of the report (which appeared in the last issue of *The Electrician*) and accounts, which, after some discussion, was carried.

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In reply to a shareholder, the CHAIRMAN said there was 2s. a share dividend due on each preference share, and they would get the ordinary dividend payable from January last.

Alderman V. B. Dillon and Mr. J. N. Keane having been re-elected Director and auditor respectively,

The CHAIRMAN proposed the resolution ratifying the provisional agreement for the transfer of the undertaking of the Company to the National Telephone Company (Limited), which was seconded and carried, and the proceedings terminated with a vote of thanks to the Chairman.

Elmore's American and Canadian Patent Copper Depositing Company (Limited).

The first annual ordinary general meeting of this Company was held on Tuesday at the Cannon-street Hotel, E.C., Mr. J. J. Atkinson presiding.

In moving the adoption of the Directors' report and accounts, the Chairman said he thought the shareholders would approve of the policy of the Board in deferring the erection of plant in America until the European companies had demonstrated the commercial value of the process. Otherwise they might have spent their money in putting up plant which would not have finally satisfied anybody, and in that way they also might have had to ask for more money, whereas they had spent very little of their working capital, and there was a strong probability that they would not need to spend anything at all on plant in America in order to sell their rights. Their American agents informed them that the quality and excellence of Elmore copper was undisputed; but before the parties desiring to acquire their rights would close as to terms, they must first see that the process could be utilised successfully on a large scale, such as could be shown in France or at Leeds. He was pleased to say that recently progress had been made. The English Company had had the whole of its preference shares subscribed, and they looked to see the business fully successful before the end of the year. As regarded the French Company, it was being taken over entirely by a new company formed in Paris, whose cash capital of £80,000 was over subscribed, and they were hopeful that that Company would soon be a success. Turning to the accounts, the Company had received £85,295 in share capital in cash, which was accounted for by £74,576 for their patents, £1,155 for plant, £7,000 lent to the French Company, £2,004 first establishment charges, and the cash in hand.

The report was adopted, after some discussion.

NEW COMPANIES, STATUTORY RETURNS, &c.

AFRICAN TRANSCONTINENTAL TELEGRAPH COMPANY (LIMITED).—The statutory return of this Company, made up to May 11th, and recently filed, shows that 34,816, out of a total of 140,000 shares of £1 each, were taken up. Upon 1,281 of these shares the full amount has been called, and upon the remaining 33,535 shares 5s. per share has been called, resulting in the payment of £7,664. 15s., and leaving £2,000 in arrears.

ALBERT ELECTRIC LIGHTING COMPANY (LIMITED).—The statutory and first annual returns of this Company, which have recently been filed, show that out of a nominal capital of £10,000, in £5 shares, 407 have been taken up. Upon 400 of these the full amounts have been called and paid, while no calls have as yet been made on the seven signatories' shares.

ASKWITH AND CO. (LIMITED).—The statutory return of this Company, made up to April 7, 1893, has just been filed. The nominal capital is £20,000, in £1 shares, of which 10,005 shares have been taken up, 5,005 shares have had the full amount called upon them, while a call of 12s. per share has been made on 5,000 shares, resulting in the payment of £8,005.

AUTOMATIC ELECTRIC RAILWAY SIGNAL COMPANY (LIMITED).—The statutory return of this Company, made up to February 22, 1893, has recently been filed. 4,905 £1 shares, out of a total of 10,000, have been taken up, of which 3,300 have been issued as fully paid. Upon the remaining 1,605 shares, a call of 10s. per share has been made, resulting in the payment of £787. 10s., and leaving £15 in arrears.

R. C. CUTTING, DOUGLASS, AND CO. (LIMITED).—The statutory return of this Company, made up to April 4, 1893, was filed recently, when 49 shares, out of a total nominal capital of £12,000 in £5 shares, were taken up. Upon 47 of these shares the full amounts have been called, and upon the remaining two shares a call of £2. 10s. per share has been made, resulting in a total payment of £240.

ELECTRICAL WONDER COMPANY (LIMITED).—The statutory return of this Company, made up to March 25th, has been filed. The nominal capital is £10,000, divided into 9,900 ordinary and 100 founders' shares, of £1 each. 5,000 ordinary and 100 founders' shares have been taken up, and the full amounts called, resulting in the payment of £3,736. 10s., and leaving £1,363. 10s. as yet unpaid.

GULCHER ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—A meeting of this (the old) Company is to be held at Messrs. Trinder and Capron's, 47, Cornhill, on the 30th inst., at 2:30, for the purpose of receiving an account of the winding-up and of the transfer of the business and assets to the Gulcher (New) Electric Light and Power Company (Limited).

INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 12th, has been filed, and shows that, out of a nominal capital of £450,000, divided into 18,000 shares of £25 each, 17,000 of such shares have been taken up, the full amount called, and all calls (£425,000) paid. The return further states that share warrants, comprising 3,187 shares of £25 each are still outstanding, that share warrants to the total value of £200 have been issued since the making-up of the last return, and that share warrants, comprising 139 shares, have been surrendered to the Company since the last summary.

LANCASHIRE AND CHESHIRE HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED).—The annual return of this Company, made up to January 13, 1893, and recently filed, shows that the 100 founders' shares (which were issued as fully paid to the House-to-House Company), and the shares taken by the seven signatories, are the only ones taken up.

LONDON METALLURGICAL COMPANY (LIMITED).—This Company is to be compulsorily wound up.

MANLOVE, ALLIOTT, AND CO. (LIMITED).—The annual return of this Company, made up to May 6th, has been filed. The nominal capital is £100,000, in £10 shares, of which 4,599 have been taken up, 4,546 have been issued as fully paid, and £530 has been called and paid on the remaining shares.

PHONOPORE COMPANY (LIMITED).—The annual return of this Company, made up to December 31, 1892, was recently filed, the delay being due to the fact of the non-holding of the annual meeting. The nominal capital is £150,000, divided into 100,000 ordinary and 50,000 preference shares of £1 each, of which 90,000 ordinary and 28,063 preference shares have been taken up. 69,025 ordinary and 10,380 preference shares have been issued as fully paid. The full amount has been called on the remaining 20,975 ordinary shares, while a call of 10s. per share has been made on 17,683 preference shares, resulting in the payment of £30,218, and leaving £8,440 in arrears.

A. RANSOME AND CO. (LIMITED).—The statutory return of this Company, made up to May 10th, and recently filed, shows that 5,900 shares, of £10 each (the whole nominal capital), have been taken up, of which 5,593 shares have been issued as fully paid. The full amounts have been called, and all calls have been paid on the 307 remaining shares.

ROGER DAWSON (LIMITED).—The Statutory return of this Company, made up to May 15th, has been filed. Of the nominal capital of £15.000, in £1 shares, 14,993 shares were issued as fully paid, while £1 per share has been called and paid on the remainder.

ST. PAUL'S PRINTING AND PUBLISHING COMPANY (LIMITED).—The first annual return of this Company, made up to and filed on March 28, shows that 1,704 shares of £1 each, out of a capital of £10,000 in £1 shares, have been taken up, and the full amount called. The calls paid amount to £1,325, leaving £379 in arrear.

SPANISH NATIONAL SUBMARINE TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to April 13th, recently filed, shows that 23,719 shares of £10 each have been taken up out of a nominal capital of £500,000, divided into 49,900 ordinary shares of £10 each and 1,000 founders' shares of £1 each. 23,715 of these shares were issued as fully paid, while the full amount has been called and all calls paid on the remaining four shares. Share warrants to the total value of £22,990 are still outstanding, while share warrants comprising 55 shares have been surrendered to the Company since the making up of the last return.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income-tax, for the quarter ended March 31st last, and payable on the 24th inst. The transfer books will be closed from the 17th to the 23rd inst., inclusive.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended May 28th were £844, as against £713 for the corresponding period of last year, being an increase of £131. The total receipts for the half-year amount to £18,579, against £17,087 in the corresponding period of 1892, being an increase of £1,492.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company invite subscriptions for £200,000 of the Four per Cent. Registered Mortgage Debentures (Mauritius subsidy) of £25 each of the Eastern and South African Telegraph Company (Limited) at par, payable 10 per cent. on application, 20 per cent. on allotment, 20 per cent. on the 27th inst., and the balance of 50 per cent. on July 25th. This issue forms part of a total of £300,000, to be secured by a first charge upon the subsidies amounting to £28,000 per annum granted by Her Majesty's Government for a period of 20 years in respect of the Zanzibar-Seychelles-Mauritius cables, and upon the net receipts from such cables. The interest is payable half-yearly on May 1st and November 1st in each year, and the principal is to be repaid on November 1, 1913. The proceeds of the issue are to be applied in part payment for the manufacture of laying of about 2,310 miles of cable to connect the existing lines from Europe along the East and West Coasts of Africa at Zanzibar with the island of Seychelles, and thence to Mauritius. A sinking-fund will be created to provide for the repayment of this issue. Prospectuses may be had of the bankers, Messrs. Barclay, Bevan and Co., 54, Lombard-street, E.C., or at the offices of the Company, Winchester House, Old Broad-street, E.C. The list of applications closes on or before four o'clock on Wednesday, the 7th inst.

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STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to allow the ordinary shares Nos. 1 to 15,000 of the Monte Video Telephone Company (Limited) to be quoted in the Official List.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—Th traffic receipts for the week ended May 26, 1893, after deducting 17 p cent. of the gross receipts, payable to the London Platino-Brazili Telegraph Company (Limited), were £2,422.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name	Previous Week's Price, May 24.	Price Wednesday, May 31.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May 31.	
						£ s. d.		Highest	Lowest
			TELEGRAPHS						
£1,247,720	Stock	12/6	Anglo-American	50½ 51½	50½ 51½	5 6 10	Jan., Apr., July, Oct.	50	..
£2,876,140	Stock	25/0	Do. Preferred	91½ 92½	92 93	5 18 3	" "	93	92½
£2,876,140	Stock	5/0	Do. Deferred	11½ 11¾	11½ 11¾	..	" "	11⅞	11½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	101 104	101 104	3 16 11	January and July	103	..
130,000	£10	3/0	Brazilian Submarine	11¾ 12¼	11½ 12	5 8 4	Mar., June, Oct., Dec.	12	11½
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107 111	107 111	4 10 1	June and December	..	..
$7,716,000	$100	$1⅜	Commercial Cable Capital Stock	140 150	140 150	4 13 4	April and October	..	..
16,000	10	8/0	Cuba Submarine	11½ 12½	11½ 12½	6 8 0	February and August	..	..
6,000	10	10%	Do. Preference 10%	18½ 19½	18½ 19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½ 3½	2½ 3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11½ 11¾	11½ 11¾	5 19 2	Jan., Apr., July, Oct.	11⅞	11½
400,000	10	2/6	Eastern	15½ 15⅝	15⅝ 15⅝	4 4 6	" "	15⅝	15⅛
70,000	10	6%	Do. 6 per Cent. Preference	16½ 17	16½ 17	3 10 7	" "	16⅞	..
£1,294,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	113 116	112 115	3 9 7	May and November	113	..
£105,900	100	5%	Do. 5 per Cent. Debentures 1899	108 111	108 111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	15⅝ 15⅞	15⅝ 15⅞	4 8 2	Jan., Apr., July, Oct.	15⅞	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114 117	111 114	3 10 2	February & August	113⅛	112
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	103 106	103 106	4 14 4	January and July	104	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101 104	101 104	3 16 11	February & August	102	..
180,227	10	2/3	Globe Telegraph and Trust	9⅝ 9⅞	9⅝ 9⅞	4 11 2	Jan., Apr., July, Oct.	10	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	15⅝ 15⅞	15⅝ 15⅝	3 16 2	" "	15⅞	15⅝
160,000	10	7/2	Great Northern	19¾ 19¾	19½ 20	4 5 0	Jan., April, and July	19⅝	19½
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	107	..
17,000	25	37/6	Indo-European xd and Bonus	41 43	40 43	5 16 3	May and November	43	40½
38,348	10	4/0	London Platino-Brazilian	4 6	4 6	6 13 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
100,000	100	4%	Pacific European Tele. 4 per Cent. Guar. Debs.	..	101 104	3 16 11	" "	..	..
10,802	8	4/0	Reuter's	7 8	7 8	..	April and October	..	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6%	119 124	119 124	4 16 9	" "	119	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	2 3	3 4	..	January and July	3⅜	3
£150,000	100	8%	Do. Debentures 8% 1902	102 106	103 107	7 9 7	June and December	..	..
88,321	10	6d.	West India and Panama xd	1⅛ 1⅜	1⅛ 1⅜	..	" "	1⅜	1¼
34,568	10	6%	Do. 6 per Cent. 1st Preference xd	11½ 12	11½ 11⅞	5 2 2	May and November	11½	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref. xd	9½ 10½	9½ 10⅛	5 14 3	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	108 111	108 111	4 10 1	June and December	109⅜	..
64,242	15	4/6	Western and Brazilian	7½ 8	7⅛ 7⅜	4 16 7	May and November	7⅜	..
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5⅝ 6¼	5⅝ 6⅛	6 0 1	" "	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1⅞ 2¼	1⅞ 2¼	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106 109	106 109	5 10 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106 109	106 109	5 10 1	" "	108¼	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120 125	120 125	5 12 0	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
40,000	£5	10/0	Chili Telephone (fully paid)	3 4	1½ 2½	..	" "	..	..
22,500	£5	1½d.	Consolidated Telephone Const. & Maintenance	1/16 1/8	3/16 1/4	..	May and November	..	..
£20,000	£1	4½d.	Oriental (11s. paid)	⅛ ¼	⅛ ¼	7 18 2	Yearly	..	..
454,747	5	2/6	National	5 5½	5 5½	5 14 3	June and December	5 7/16	5
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref	15 15½	14¾ 15½	3 18 8	" "	15½	14½
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14½ 14¾	14½ 14¾	4 1 4	" "	14½	..
90,950	5	6¾d.	Do. 5% Non-Cumulative 3rd Pref (£3 paid)	5¼ 5½	5⅜ 5⅝	..	..	5½	5 1/16
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	113 116	112 115	3 18 3	January and July	..	..
48,000	£10	..	New Telephone, Limited (£4 paid)	.. ..	.. ..	..	..	..	..
58,000	5	1/0	United River Plate	2 3	2 3	..	January and July	..	..
	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (fully paid)	12 12½	12 12½	..	..	12¼	..
20,000	£10	..	Do. 6 per Cent. Preference (£4 paid)	12½ 13	12½ 13	..	..	13	12¾
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	..	5 5½	..	..	..	..
£47,900	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
8,332	£5	..	House to House Electric	..	1½ 2½	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully pd.)	..	5⅜ 5⅝	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	6 6½	..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4¼ 4½	4¼ 4½	..	..	..	..
10,000	£5	5/0 '92	Do. (fully paid)	6½ 6⅝	6½ 6⅝	..	..	..	..
111,000	5	..	London Electric Supply	⅞ 1⅛	⅞ 1⅛	..	..	..	..
43,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6¼ 6⅝	6 6½	3 1 6	..	6½	..
£50,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, & £40)	103 106	103 106	4 14 4	June and December	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	5 6	5 6	..	..	..	..
18,680	£5	9½%	St. James' and Pall Mall	7½ 8	7½ 8	..	..	..	..
7,900	£5	7%	Do. 7% Preference	8 8½	8 8½	4 2 4	..	8⅜	..
42,853	5	2/0	Westminster Electric Supply (fully paid)	5½ 5⅝	5½ 5⅝	3 0 10	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/6	Brush Electrical Engineering	3⅛ 3⅜	3⅛ 3⅜	..	..	3 1/16	3⅛
69,996	2	6%	Do. 6 per Cent. Preference	2⅝ 2⅞	2⅝ 2⅞	5 1 1	..	2 15/16	2⅝
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	108 110	108 110	4 1 0	..	..	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼ 5⅝	5¼ 5⅝	6 1 9	January and July	..	..
12,139	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..	..	..	..	..	..
45,000	10	12/0	Electric Construction	2¼ 2¾	2 2½	..	..	2⅜	..
70,000	2	10/0	Elmore's Patent Copper Depositing	¼ ½	⅜ ⅝	..	..	1/16	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	..	..	..
50,000	10	15/0	India Rubber, Gutta Percha &c., Works	23 24	22½ 23½	5 6 4	February & August	23⅝	23
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½ 3½	2½ 3½	..	..	..	..
11,334	£10	8/0	Do. Preference	.. ..	.. ..	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	5/0 6/0	5/0 6/0	..	..	..	..
78,949	5	4/2½	Swan United (£3. 10s. paid)	3 3½	3 3½	10 0 0	May and November	..	..
37,350	12	24/0	Telegraph Construction and Maintenance	30 32	30 32	5 12 5	March and July	31½	30¼
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102 105	02 05	4 15 3	January and July	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	..	..	..	..
..	£5	..	Do. Preference (fully paid)	..	..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
63,000	£10	..	City and South London Railway	..	..	..	..	..	..
600,000	Stock	4%	Do. Stock	37 39	37 39	2 17 8	May and November	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 786.—Vol. XXXI. FRIDAY, JUNE 9, 1893. PRICE FOURPENCE. *Annual Subscription (U.K.), 19/6*

NOTES.

The net outcome of the last meeting of the Electrical Trades Section has been the conversion of the Electric Traction Association into a special Sub-Committee of the Electrical Trades Section of the London Chamber of Commerce; a proceeding against which the General Manager of the National Telephone Company entered a vigorous protest, under the erroneous impression that the whole weight of the Chamber itself was to be thrown into the scale on behalf of a single trade. Enlightened self-interest and the support of the Municipal Corporations Association will, it is to be hoped, enable the tractionists to score a victory at the forthcoming Parliamentary inquiry; for it is tolerably plain that no one not immediately concerned cares much whether the telephone or the traction circuits are doubled. In either case "it will be good for trade," as some genial gentleman no doubt remarked when Nero fiddled whilst Rome burned. However, we have a shrewd suspicion that in the long run trade will benefit more by a healthy development of electric traction than by a Parliamentary benediction being given to single-wire telephony.

At the Royal Society's *conversazione*, on Wednesday last, the most interesting exhibit, from an electrical point of view, was a new instrument called the hydrophone, of which we gave a brief account in our issue of November 18, 1892. The purpose of this apparatus, which is the invention of Captain McEvoy, is chiefly to give warning of the movements of distant vessels, and to prevent surprise attacks. In principle it is very little more than a microphone connected up in series with a battery and telephone. All the contacts in the microphone are, however, metallic, and the apparatus is enclosed within a bell-shaped iron vessel, which is sunk to a suitable depth at the place at which the vibrations of the water are to be observed. Water does not enter the vessel, owing to its containing compressed air like a diving bell. The movements caused by the screw of a passing steamer agitate the loose metallic contacts in the microphone, altering their resistance, and consequently changing the current strength in the circuit connecting the apparatus with the shore. This change in current produces sound in a telephone placed in circuit in the usual way, or may be made to work a relay so as to ring a bell or flash a light, &c. The apparatus is simple and compact, and seems unlikely to get out of order. It is stated that a torpedo boat cannot approach within a range of half a mile of the submerged vessel, or a man-of-war within a distance of a mile, without the pulsations of the propellers being detected. The apparatus has been tried by military experts at Stokes Bay, and the sounds caused by various kinds of propellers have been distinguished at a distance of more than seven miles.

A new Harmonic Analyser, constructed at Zürich to designs by Prof. Henrici and Mr. Sharp, was also exhibited. By making the tracing point of this instrument travel once over a curve, the first *five* terms of the Fourier's series, which represents this curve, can be at once read off. On going twice more round the curve, the next five terms can be obtained. Naturally the instrument is most complicated. It, however, appears to work admirably, and will be very useful in many departments of scientific work. In electricity an important adaptation will be to analyse the shape of the curves representing alternating currents.

Mr. Nikola Tesla's lecture, delivered in February last before the Franklin Institute at Philadelphia, and before the National Electric Light Association in March, has now been published in the American papers, and the first part of an abstract of it will be found in another column. On the whole, it is a disappointment, but Mr. Tesla's work is difficult to appreciate. The lecture begins with a long introduction on the value of vision as a connecting link between our consciousness and the world we live in. This leads to the consideration of light, and our abstract begins with the experimental part of the lecture. From a very large number of experiments having no very clear connection, we have selected those which are either novel, or which may be said to be self-contained. Many of those who have watched Mr. Tesla's work would like to see him concentrate his energies on some definite object, experimental rather than speculative, and having a direct bearing either on the elucidation of some branch of electrical or electro-optical science, or some utilitarian application. When we heard that many of his new lamps were patented, we expected that he would undertake an Edison-like investigation and produce some useful result. On the other hand, he might have turned off on the purely scientific lines of Prof. J. J. Thomson, lines which, we should think, would be more agreeable to Mr. Nikola Tesla than mere inventing. If a few quantitative determinations of current, voltage, or even of frequency, had been given in the lecture, it would have had a definite

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scientific value. To reduce even one out of the fifty experiments to a complete research, would be worth all the other forty-nine brilliant and suggestive demonstrations.

Mr. J. Erskine Murray's letter on the electro-chemical equivalent of zinc, which will be found in our correspondence columns, serves as a useful warning to physicists against the acceptance, as trustworthy, of any materials decorated with the epithets "pure," "puriss." "chemically pure," "pure for analysis," and so forth, which are offered by dealers in chemicals and reagents. Commercially "pure" zinc is generally fairly free from arsenic, the substance most objectionable for its commonest use, viz., the evolution of arseniuretted hydrogen in toxicological analysis; but it is a great mistake to suppose that it approximates to Zn. Chemists are often careless or confiding enough to be satisfied with a label, or the statement of a price list, as a guarantee of purity, but physicists and electricians are still more liable to be deceived, as they rarely require reagents of approximately absolute purity, and are unaware of the nature of the besetting impurities of any particular element or compound, and of the means for their removal. In all chemico-physical researches, the investigator, whether chemist or physicist, should consult with a colleague trained in whichever of the two branches of science he feels himself to be less competent, and be guided by advice drawn from more intimate experience.

The method of correcting for the action of the electrolyte *per se* on the cathode, adopted by Mr. Murray, is a good one, and its principle quite defensible, if not perfectly sound. A suggestion that was recently made by Mr. Blount, in a contribution on the accuracy of the copper voltameter, viz., to conduct the electrolysis in a neutral atmosphere, appears applicable here. The gain in weight of a zinc plate in a neutral solution of zinc sulphate could hardly proceed in the absence of free oxygen, and the use of a boiled-out solution of zinc sulphate *in vacuo*, or in an atmosphere of nitrogen, should prevent it altogether. Operating thus, Mr. Murray would probably have obtained a result free from the error he mentions, and thus the ingenious mode of correction he actually adopted would have been rendered unnecessary. With regard to the relation of the atomic weights of copper and zinc, the Paper by Dr. Gladstone and Mr. Hibbert, referred to by Mr. Murray, gives the value 1·0322 for the ratio Zn : Cu, which, when considered in conjunction with value 63·6 for copper, gives Zn = 65·6, O being 16.

In another column Mr. E. T. Carter reviews the various methods of charging for a supply of electricity which the exigencies of the situation have forced upon our central-station concerns. He points out that, while few of these devices come up to the ideal of charging every consumer in exact accordance with the plant-outlay his particular installation involves, none of them tend to encourage a day-load, that much-to-be-desired consummation.

In connection with this same knotty question a lengthy discussion recently took place in the Brussels Town Council. At Brussels it is proposed to charge 10 centimes per 100 watt-hours (10d. per Board of Trade unit), with a minimum of 5 francs per lamp per annum. This 5 francs minimum, it was argued, would seriously deter people from adopting the electric light. It is sometimes said that all these tariff devices are the result of the over scientific training of the electrical engineer. Had that gentleman, however, an electrical counterpart of the gasometer, the householder would be very little troubled with "Manchester," "Brighton," "Leeds," or "Metropolitan" scales; but until some such apparatus has been evolved, it will be necessary to keep down, by some means or other, the number of "idle" lamps. As regards the Brussels minimum, the historic argument that "it is *such* a little one" may surely be urged. In London, with electricity at something over 7d. per unit, 7s. 6d. has been found to be about the average income per 8-c.p. lamp wired, so that, with electricity at 10d., a 5fr. minimum is a very modest one. A consumer need only burn each 8-c.p. lamp wired for 150 hours in the year in order to exceed it.

The town of Hanley, Staffordshire, is being supplied with an electric supply service by its own municipal authority, and Mr. Lobley, the borough engineer, has issued a Report upon the undertaking. Alternating currents, transformer sub-stations, and low-pressure distributing mains, are being used. The old fallacy that the weight of copper in the mains is inversely as the square of the voltage, is trotted out in this Report to show "the enormous amount of copper buried in mains" when low pressure is used. There was some foundation for this academical idea when transformers were fixed in each house, and those who use it are always careful to talk of the weight of copper, and not of the cost of the mains. But with alternate-current sub-stations the low-pressure mains are practically the same as in a continuous-current low-pressure system, the only difference being that it is generally more difficult to procure sites for sub-stations than to fix feeding points for feeders; feeders, moreover, will in some cases have to be run from the sub-stations. The only advantage of alternating currents will then be the facility they afford for erecting a station outside a town, where land is less valuable. But this means extra expense in mains.

In his report, Mr. Lobley discusses the comparative cost of gas and electricity for street lighting. He takes 40 glow lamps of 60 watts each, and estimates the total annual cost at £98 for 4,000 hours of lighting. This is made up of £30 for interest on first outlay, £12 for lamp renewals, and £6 for painting. The remainder works out at 1½d. per unit supplied. It is admitted that the present cost of gas for these 40 lamps is £120. We should be very much surprised if these can be replaced by electric lamps for less than £150 per annum, and we cannot see any advantage in such replacement. Street lighting by glow lamps seems at present to be a great waste of good current, and one which must necessarily load the station at its busiest time, even if it helps to fill up the midnight and early morning hours. Cheap lamps run at high efficiency may, perhaps, help to remove the great difference between the cost of lighting by arc and by glow lamps but the visits of the

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lamp-renewer would have to be almost as frequent as those of the lamplighter. Mr. LOBLEY has a patent device for switching on glow lamps for street lighting, by means of electro-magnets in the street arc-lamp circuit, and good-naturedly reserves free use of his invention for Hanley.

Electric Lighthouses.—It is proposed to fit the lighthouse on the Old Head of Kinsale with an electric light.

Burnley.—There is every probability that the municipal central lighting station will be finished in a month's time.

Electric Traction at Hanover.—A Siemens and Halske 13 car electric line came into operation at Hanover last month.

Edinburgh.—Prof. Kennedy has been appointed engineer to the Corporation in connection with the electric light which the Council propose to introduce.

The Dutch Telegraph Department.—M. J. P. Havelaar has been appointed Director-General of the Netherlands Post and Telegraphs, in succession to the late M. Hofstede.

Cable Interruptions and Repair:—

	Date of Interruptions.	Date of Repair.
Santiago de Cuba-Mole St. Nicholas	April 20th	June 7th
*Paramaribo Cayenne	April 15th	—
*St Thomé-Loanda	May 30th	—

* Not yet repaired.

Electrical Coast Communications.—Sir Edward Birkbeck, Chairman of the National Lifeboat Institution, and a member of the Royal Commission on Coast Communications, has been inspecting the American and Canadian coast communication systems.

Blackburn.—The Local Government Board has given their consent to the borrowing of £50,000 for electric lighting purposes, and the Borough Engineer is to prepare specifications and working drawings to enable the Corporation to obtain tenders for carrying out the work.

Brighton.—An inquiry by Mr. Thomas Codrington, an inspector of the Local Government Board, was held at Brighton on Wednesday into an application of the Town Council for sanction to borrow £8,200 for purposes of electric lighting. There was no opposition.

Obituary.—The death is announced of Prof. Moses G. Farmer, co-inventor of the once well-known Wallace-Farmer dynamo, and for many years Professor of Electricity at the United States Torpedo Station, Newport, R.I. Prof. Farmer died at Chicago on the 25th ult. He was in his 73rd year.

Electrical Bills in Parliament.—The following Bills have passed through Committee in the Lords:—Electric Lighting Provisional Order (No. 1) Bill; Electric Lighting Provisional Orders (No. 3) Bill. In the Commons the City of London Electric Lighting Bill has been read a second time.

Electric Traction.—The two Houses of Parliament propose to nominate the following members to be the Joint Committee on the Electric Powers Protective Clauses:—Earl Rosse, Earl Russell, Viscount Cross, Lord Clifford of Chudleigh, Lord Ker (Marquess of Lothian), Mr. Brunner, Mr. Forwood, Mr. Molloy, Sir Bernhard Samuelson, Major Darwin.

Royal Institution.—At the general monthly meeting on Monday last the special thanks of the members of the Institution were returned for the following donations to the fund for the promotion of experimental research at low temperatures:—Messrs. Crossley Bros, £50; James Mansergh, Esq., £21; Sir Henry Doulton, £50; Captain A. Noble, £50.

Honours.—Amongst the recipients of "Birthday Honours" were Mr. Charles Todd, Postmaster-General and Superintendent of Telegraphs of South Australia; Mr. George Berkley, Past President of the Institution of Civil Engineers; and Mr. Francis John Stephens Hopwood, Assistant Secretary, Railway Department, Board of Trade, who have been made Knights of St. Michael and St. George.

Southport.—After a 4½ hours' sitting, the Town Council decided that the resolution, that an electric light plant should be put down in the town area, should be referred back to the Committee, with instructions to bring up a statement by the electrical engineer of the comparative cost, advantages, and disadvantages of lighting the town area from Crowlands and Eastbank-street respectively, having regard both to the capital and working expenses.

Leicester.—At an open-air meeting of the Leicester Ratepayers' and Property Owners' Protection Association, on Tuesday last, it was unanimously decided to emphatically protest against the proposal of the Corporation to borrow £50,000 for the purpose of establishing the electric light, the meeting being of opinion that it was inadvisable at the present time to add to the already heavy debt of the town, especially by works of a speculative character.

Sunderland.—A special meeting of the Electric Lighting Committee of the Sunderland Town Council was held last Friday, when a report was considered which had been prepared by Prof. A. B. W. Kennedy. Taking into consideration the low price of gas in Sunderland, Prof. Kennedy considers that not more than 6d. per unit could be charged, at which rate an income of £2,500 might be expected from 5,600 lamps. After carefully considering the report, the Committee decided to bring it before the next meeting of the Council, and to recommend that a new Provisional Order should be applied for.

Thunderstorms. Thunderstorms of considerable severity visited the north-east on Saturday and Sunday, and buildings were struck by lightning at Bainton, near Stamford, Ilkeston, and Kirkheaton, near Huddersfield. On Saturday afternoon a violent thunderstorm occurred at Keighley, and an isolated farmhouse on the highway between Keighley and Ilkley was struck by lightning and completely wrecked. The chimney was cut away; stones weighing over one hundredweight were sent in all directions over a distance of 20 yards. The house was set on fire, and the furniture destroyed. The occupants were seriously injured.

Terrestrial Magnetism.—In his report for the year 1892 the Astronomer Royal states that a record of the sun's surface has been secured on 220 days. The mean daily spotted area of the sun has been 1,230 in 1892, as against 100 in 1890 and 566 in 1891. With regard to the magnetic observations, the photographic registration of magnetic declination, horizontal force, and vertical force, and of earth currents, with the accompanying eye observations of declination, force, and dip, has been maintained. The period has been one of great magnetic activity. In the year 1892 there were 22 days of great magnetic disturbance, and 25 days of lesser disturbance. The growth of the Observatory buildings, involving the introduction of large masses of iron being likely to cause disturbing effects on the magnetic observations, the Astronomer Royal represents as desirable that an auxiliary magnetic station should be established in the neighbourhood, at a distance which would prevent such danger.

Telephonic Statistics.—The following comparative table will enable our readers to form a good idea of the relative development of telephony in the four leading capitals of Europe. The telephone total for London has been deduced from the latest subscribers' list available. It should be mentioned that the National Telephone Company has recently (see *The Electrician*, Vol. XXX., March 31st, p. 621) inaugurated a system of £10 and £12 rentals, applying only to districts outside the City, and to domestic communications:—

Town.	Population.	Telephone subscribers.	Subscribers per 1,000.	Annual rental.	System.
London..	4,250,000	6,834	1·6	£20	Single wire, overh'd. multiple exchanges.
Paris ...	2,400,000	9,653	4	£16	Double-wire, underg'nd, 12 exchanges.
Berlin ..	1,600,000	20,000	12·5	£7 10	Single-wire, overhead, 8 exchanges.
Vienna..	1,400,000	6,100	4·3	£8 8	Double-wire, underground, 1 exchange.

Indian Cable Repairing.—Mr. A. L. H. Palmer, Superintendent, Government Telegraph Department, Madras Division, has, says the *Indian Engineer* of April 22nd, just returned to Madras from a tour of inspection in the South. Telegraphic communication between India and Ceylon is established by two cables from Ramiaswaram, in India, to Talmanaar, in Ceylon, one of gutta-percha and the other of india-rubber. The first had

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become absolutely useless, while the second, though workable, was not in perfect order. The defects in the cables were within ten miles of the Talmanaar end of the cable. The work of repairing these defects was carried out with the steam launch "Emily," from Colombo, but as this had no accommodation on board for officers or coolies, the latter had to be accommodated on rafts, and the working party had to return to the shore at night and recommence work every morning. Mr. Palmer was engaged on this work from March 17th to April 4th, and has received a telegram from the Director-General of Telegraphs recognising the difficulties which he has had to contend with, and congratulating him on the success of the operations.

Bradford.—The Gas and Electric Supply Committee of the Bradford Corporation had a two hours' sitting on Friday last to consider a scheme propounded by Mr. Shoolbred for improving and extending the electric light supply to the town. The Committee have already had under discussion a scheme devised by Mr. Baines, the resident engineer, by which he proposes to substitute the three-wire system for the two-wire system, and also to extend the electric light mains a considerable distance, the total cost of all the work being between £5,000 and £6,000. The scheme which Mr. Shoolbred laid before the Committee does not provide for an extension of the area to be lighted, but for the substitution of the five-wire system. The Committee, after hearing Mr. Shoolbred's explanation, debated as to which scheme should be adopted, but eventually decided to adjourn the matter, and leave to a sub-committee the responsibility of calling Lord Kelvin to advise the Committee as to what was best to be done. A strong minority of the Committee urged that the present works were ample for the needs of the borough for next winter, and that it would be best to await the experiment of the five-wire system at Manchester, and any further developments of electrical appliances before embarking on a further outlay.

An Electric Meter Disputed.—On Friday last, at Brighton, Mr. Joseph Hall was summoned, as secretary of the Mikado Creamery Company, King's-road, for non-payment of £20. 10s. 9d. for electricity supplied by the Corporation and for rent of meter. Mr. E. C. Baldwin proved delivery of demands of £14. 15s. 6d. for the quarter ending December 31st, and £5. 15s. 3d. for the quarter ending March 31st. The defendant disputed the amount in the December quarter as excessive. It was pointed out that by the Act the amount registered was conclusive evidence of the rate due, subject to application being made for the testing of the meter. Defendant said he was no party to the passing of the Act. The Stipendary said he had heard that objection before, but he was afraid it would not hold. He gave judgment for the plaintiff for the amount claimed. Subsequently the defendant returned and said the meter was changed in December, and the Stipendary consented to allow the whole matter to be reopened. Mr. Arthur Wright, manager of the Electricity Works, said in December the defendant's meter stopped, and was replaced by one of the Ferranti type. The Stipendary suggested that the charge for October and November might be agreed between the parties. The case was eventually adjourned for a week.

The Most Economical Age of Incandescent Lamps.—In closing the discussion on Carl Hering's Paper, "The Most Economical Age of Incandescent Lamps," recently read before the American Institute of Electrical Engineers, the Chairman made the following remarks:—"There is much food for thought in Mr. Hering's Paper, and his ideas, as elucidated by him, and by the members who have favoured us by discussion, are clearly of such practical importance that they merit the mature consideration of all who are interested in illumination by glow lamps, whether producers or consumers. While the idea of cutting short the life of an incandescent lamp is an absolutely new one to me, I have thought, while listening to the discussions, that it is one capable of much wider application than the Paper suggests; for example, to human beings who have outlived their usefulness, and whose life is devoted to making the lives of their fellow creatures miserable. My early years were embittered by an aged and crabbed male relative, and I think now, if I had had then the suggestions contained in Mr. Hering's Paper, I might have taken into consideration the circumstance that it was a waste of energy to keep him going, and that in the interests of law and order, seeing that he had reached that period which Mr. O'Keenan, impelled by the hereditary instincts of his race, calls the 'smashing point,' it was my duty to disconnect him."

Telephone Extensions in Manchester.—The *Manchester Guardian* states that the National Telephone Company has determined to reconstruct and rearrange an extensive portion of their Manchester system, and propose to lay underground cables in the central parts of the city if the consent of the Corporation can be obtained. Should the Company's suggestions be accepted, three-fourths of the wires which are at present overhead will be removed and placed underground. It is intended that the wires shall be enclosed in 3in. iron tubes, each tube to contain 100 lines. The proposal was first laid before the Council in October last. Since that time plans have been submitted of the projected underground work, and much correspondence has passed, but no agreement has yet been come to. On May 20th, the General Manager of the Company wrote to the Town Clerk pressing the matter upon the attention of the City Council, and stating: "I am sure you will appreciate the urgency of the question when I tell you that the Company have been compelled, in consequence of the rapid increase in the number of subscribers, to commence their works, which are estimated to cost upwards of £40,000, and in the course of a few weeks will have no option but to proceed overhead, after which any arrangements to place the wires underground would not be feasible." The Paving, Sewering, and Highways Committee, in whose hands the matter rests, have presented a report to the City Council, embodying the correspondence, and concluding as follows:—"Your Committee, in view of the discussions which have taken place in the City Council, and the desire expressed that the whole subject should be considered, deem it desirable that the Council should give such instructions to your Committee as to the course to be pursued in relation to this matter as upon consideration of the subject it may deem necessary."

Mr. Harness and the "British Medical Journal."—In November last the *British Medical Journal* published the following paragraph:—"We have good grounds for stating that *The Times* has recently refused a four-column advertisement from the Harness Electropathic Belt Establishment, of the value of £80, a course worthy of the high and honourable traditions of that journal." "This paragraph," says the *British Medical Journal*, "was, in fact, inserted in the *Journal* with the sole object of raising boldly between ourselves and Mr. Harness the question whether the business carried on by him was a legitimate and honest one, or the very reverse; and we were prepared, at any cost and trouble, to have this question fully and fairly tried by a jury, and to abide by their decision on the issue presented to them. Accordingly, on the action being commenced, we admitted that we had published the paragraph complained of, and justified what we had written. Our readers will perhaps not be altogether surprised to learn that Mr. Harness, after we put in our defence to his action, took no further steps in the matter. Determined to bring him to book, after waiting a reasonable time, we applied for an Order that Mr. Harness should be compelled either to go on or to discontinue this action, and an Order was accordingly made that unless he proceeded to give notice of trial and to enter his action for trial within twenty-one days, it should be dismissed with costs. After what we have already stated, our readers will doubtless anticipate the sequel. The twenty-one days elapsed. Mr. Harness abandoned his action, and the same was dismissed with costs, since paid by him. These costs, being what are termed party-and-party costs, necessarily do not represent the expenses which the Association has been put to in preparing to meet and justify the paragraph which Mr. Harness has allowed to go against him unrefuted. That, however, is a very small matter. The result of this abortive action is a convincing proof that Mr. Harness was not prepared to meet the charges brought against him by the *Journal* in open Court, and is conclusive that all we have said on the subject of Mr. Harness and his so-called electric belts has been fully justified."

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ELECTROMAGNETIC THEORY.—LI.

BY OLIVER HEAVISIDE.

(Continued from page 98.)

§ 202. Let the parallel conducting tubes be of finite resistance. As a result, the external disturbance penetrates into them, and a waste of energy follows. As a further result, the external disturbance becomes modified. This occurs in a twofold manner. By cumulative action, the nature of a wave sent along the leads may be profoundly modified as it progresses. Besides this, there is what we may term a local modification, whereby the wave at any place is no longer strictly a plane wave. It is merely with this effect that we are now concerned. The departure from planarity requires a considerably modified and much more difficult theory, no longer expressible in terms of V and C simply, in order to take it into account. But in the construction of a practical theory, we take advantage of the fact that the departure from planarity is slight, to which we have already referred towards the end of § 199. A line of electric force does not now start quite perpendicularly from the positive lead and end similarly on the negative lead. It has a slight inclination to the perpendicular, and therefore curves out of the reference plane to a small extent. In the dielectric itself, this peculiarity is of little importance. But the slight amount of tangentiality of the electric force at the surface of the leads, which is conditioned thereby, is of controlling importance as regards the leads themselves, and eventually through them, to the waves in the dielectric, by attenuating and altering the shape of waves (considered axially), as just referred to. We should now consider what form is assumed by the second circuital law in terms of V and C, when we admit that there is tangential electric force on the surface of the leads, but on the assumption that the minor effects in the dielectric itself, which are associated with the presence of the tangential force, are of insensible influence.

We may still regard V as the transverse voltage in the reference plane. Whether we go straight across from the positive to the negative lead, keeping in the reference plane, or leave it slightly in order to precisely follow a line of force in estimating the voltage, is of no moment, because the results differ so slightly. The quantity C is subject to a similar slight difference, according to the way it is reckoned. We may, perhaps, most conveniently reckon it as the circuitation of the magnetic force round either lead upon its surface and in the reference plane, because this way gives the exact value of the conduction current in the lead. But the circuitation in other paths in the reference plane will not give precisely the same value now that the waves are not quite plane. This difference we also ignore in the practical theory. In truly plane waves the electric current in the dielectric is wholly transverse. There is now really an axial component as well, but being a minute fraction of the transverse current, it is ignored. In short, we have to make believe that the waves are planar when considering their propagation through the dielectric, whilst at the same time we take into account the departure from planarity in considering the influence of the leads and what occurs in them. It is unfortunate to have to refer to small corrections, as it confuses the statement of the vitally important matters. Let us, then, set them aside now.

Construct the second circuital equation in the manner followed in § 201, in elucidating the meaning of equation (6). Consider a rectangle consisting of two transverse sides in reference planes at unit distance apart, beginning upon the positive and ending upon the negative lead, and of two axial sides of unit length upon the leads themselves. Reckon up the voltage in this rectangle. The transverse sides give V and $V+dV/dx$. The axial sides give E_1 and E_2 say, if E_1 is the tangential component in the direction of increasing x of the electric force at the boundary of the positive tube, and E_2 the same on the negative tube, but reckoned the other way. The complete voltage is then

$$E_1+\left(V+\frac{dV}{dx}\right)+E_2-V,$$

or

$$\frac{dV}{dx}+E_1+E_2.$$

It is also equal to $-L\dot{C}$, as in § 101. (There is no magnetic conductance of the dielectric now.) So

$$-\frac{dV}{dx}=E_1+E_2+L\dot{C}, \quad . \quad . \quad . \quad (16)$$

is the form assumed by the second circuital law.

Observe that we have made no specification of the nature of the leads, so that the equation possesses a high degree of generality. As regards the first circuital law, that is unchanged, being expressed by (5) when the dielectric is non-conductive, and by (9) when conductive, since the minor changes alluded to as regards V and C are not significant.

Being general, the equation (16) needs to be specialised before it can be worked. If our electromagnetic variables are to continue to be V and C, we require to express E_1 and E_2 as functions of C. Fortunately this can be done, sometimes very simply, and at other times in a more complicated way. To take the simplest case, let the leads be tubes (or sheets) of so small depth that penetration is practically instantaneous as waves pass along them. Then E_1 is not only the boundary tangential electric force, but is also the axial electric force throughout the substance of the positive tube. Similarly as regards E_2 for the negative tube. It is true that, in virtue of the transverse electric current from tube to tube, there is also transverse current in the tubes, and, therefore, transverse electric force, but this is to be ignored, because it is a small fraction of the axial. The current density in the positive tube is therefore axial, of strength k_1E_1, if k_1 is the conductivity of the material; and the total current in the tube is K_1E_1, where K_1 is the axial conductance per unit length, or, which is the same, E_1R_1, if R_1 is the resistance per unit length. But this quantity is also the previously investigated quantity C, the circuitation of the magnetic force on the boundary of the tube. So we have the elementary relations

$$E_1=R_1C_1, \qquad E_2=R_2C_2, \quad . \quad . \quad . \quad (17)$$

which are, be it observed, essentially the connections of the electric and magnetic forces at the boundaries, though brought to a particularly simple form by the instantaneous penetration. The second circuital equation (16) therefore takes the form

$$-\frac{dV}{dx}=(R_1+R_2)C+L\dot{C}. \quad . \quad . \quad . \quad . \quad (18)$$

Or, finally, if R is the resistance per unit length of the two leads,

$$-\frac{dV}{dx}=RC+L\dot{C}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

which is the practical equation for most purposes. Observe, comparing it with (12), that there is an identity of form, but with a changed meaning of the symbol R. In the exactly stated problem of plane waves running through a medium of duplex conductivity bounded by perfect conductors, the quantity R is the transverse magnetic conductance per unit length axially. In the present approximately stated problem of very nearly plane waves running through an electrically conducting medium bounded by resisting wires, the quantity R is the resistance of the wires, per unit length axially. What we have to do, therefore, in order to turn the real problem into one relating to strictly plane waves admitting of rigorous treatment, is to abolish the resistance of the leads and substitute equivalent magnetic conductance in the dielectric medium outside. The two materially different properties are nearly equivalent in their effects. Equations (13), (14), (15), still hold good, only RC^2 is now to be the rate of waste in the leads, instead of in the medium generally due to the (now suppressed) magnetic conductance. The flux of energy is now not quite parallel to the leads everywhere, but has a slight slant towards them. But the usual formula gives the waste correctly. The product E_1H_1 of the tangential electric force E_1 and the magnetic force, say H_1, at the boundary of the positive lead, is the rate of supply of energy to the lead per unit surface. Therefore, by circuitation, the product E_1C is the rate of supply per unit length axially. This is the same as the previous R_1C^2.

The equivalence of effect of magnetic conductance externally and of electric resistance in the leads, is undoubtedly a somewhat mysterious matter, principally because it is hard to see (apart from the mathematics) why it should be so. As regards

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the above reasoning, however, it is essentially simple, and is a direct application of fundamental electrical principles. It may, therefore, cause no misgivings, except the doubt that may present itself whether the ignored small effects in the dielectric due to departure from planarity of the waves are really ignorable. As a matter of fact, they are not always of insensible effect, and plenty of problems can be made up and worked out concerning tubes and wires which do not admit of the comparatively simple treatment permissible when V and C are the variables, and the results are exceedingly curious and interesting, though quite unlike those at present in question. But these are not practical problems, and have little bearing upon the question of the free propagation of waves along long parallel straight wires. They do not start as full grown plane waves from the source of disturbance, but they very soon fit themselves on to the wires properly, and then follow the laws of plane waves pretty closely.

Although thin tubes for leads were specially mentioned in connection with equation (19), yet any sort of leads will do provided the penetration be sufficiently rapid to be instantaneous "within the meaning of the Act." It is obviously true for steady currents, when the inertial term disappears and R is the steady resistance. And if the variations of current be not sufficiently rapid to cause a sensible departure from uniformity of distribution of current in the conducting wires, then, of course, (19) may still be safely used. At the same time, it should be mentioned that the inductance L should, under the circumstances, be increased by a (usually) small amount due to induction in the conductors themselves, as will be presently noted more closely. Furthermore, remember that no allowance has been made for the influence of parallel conductors, should there be any. The earth does not count if the leads be alike and equidistant from the ground, as its influence can be embodied in the values of L and S, the inductance and permittance.

§ 203. The next question is what to do when penetration is not instantaneous within the meaning of the act. We should first go back to (16), which remains valid, and inquire whether the tangential electric forces cannot be expressed in terms of the current (or conversely) in some other way than by a linear relation. Suppose we say

$$E_1 = R''_1 C, \qquad E_2 = R''_2 C. \quad . \quad . \quad . \quad (20)$$

Is it possible to give a definite meaning to the symbol R″? Is there a definite connection between C, regarded as a function of the time, and E_1 or E_2 also regarded in this way?

Imagine a wire to be free from current, and, therefore, electrically neutral. Now expose its boundary to tangential electric force, beginning at a certain moment, varying in some particular way with the time later, and then ceasing. The result is that C, the total current in the wire, will run through a particular sequence of values, and then finally cease. If we begin again with the applied force, and make it run through the same values in the same manner, we shall again obtain the same values of C at corresponding moments. So far, then, the connection is a definite one. Moreover, if we make the applied force run through the same values increased in a certain ratio, the same for all, then the current will have its previous values increased in the same ratio. But if we change the nature of the applied force as a function of the time (irrespective of size) we shall find that C is not merely changed as a function of the time, but also as a function of the applied force. That is, the mere value of one does not necessitate any particular simultaneous value of the other. So, if we keep to the usual sense meant when algebraists say $u = f(x)$, or u is a function of x, we cannot say that C is a function of E. It is, nevertheless, true that the march of C is strictly connected with that of E, so that when the latter is given, the former is obligatory. To deny this would be equivalent to the denial of there being definite controlling laws in operation. The full connection between E and C, however, involves not merely their values, but also the values of their first, second, third, &c., differential coefficients up to any order. That is, the symbol R″, taken by itself, is a function of the differentiator d/dt. To illustrate by a simple example, suppose

$$R'' = R + Lp + (Sp)^{-1}, \quad . \quad . \quad . \quad . \quad (21)$$

where R, L, S are constants, and p stands for the differentiator. This means that

$$E = \{R + Lp + (Sp)^{-1}\}C, \quad . \quad . \quad . \quad . \quad (22)$$

or

$$E = RC + L\dot{C} + S\int C dt, \quad . \quad . \quad . \quad . \quad (23)$$

in the common notation of integrals. Now imagine the march of C to be given. This implies that the march of $\dot{C}$ is also known, and likewise that of $\int C dt$. Consequently the march of E is explicitly known. It is less obvious that when the march of E is given, that of C is known, by the same operator implicitly. That is, by (22) we have

$$C = \frac{E}{R + Lp + (Sp)^{-1}}, \quad . \quad . \quad . \quad . \quad (24)$$

and given E as a function of the time, C is known as a function of the time, or if not known, can be found without ambiguity. It is not obvious, because we do not immediately see how the operation indicated in (24) is to be carried out, whereas, in the case of (22), it is visible by inspection. Nevertheless, the fact that the march of E, physically considered, conditions that of C, makes the above equation (24) not only definite, but complete. In the usual treatment of the theory of differential equations, there is no such definiteness. Arbitrary constants are brought in to any extent, to be afterwards got rid of. Now this is all very well in the general theory of differential equations, where arbitrary constants form a part of the theory itself, but for the practical purpose of representing and obtaining solutions of physical problems, the use of such arbitrary and roundabout methods (which are too often followed, especially by elementary writers) leads to a large amount of unnecessary work, tending to obscure the subject, without helping one on. It would not, perhaps, be going too far to say that such a misuse or inefficient application of analysis often makes rigmarole.

When we say that $E = R''C$, where R″ is the resistance operator (so called because it reduces to the resistance in steady states), we assert a definite connection between E and C, so that when C is fully given as a function of the time, and the operations contained in R″ are performed upon it, the function E results, and similarly, when it is E that is given, then the inverse operator $(R'')^{-1}$ (or the conductance operator) acting upon it will produce C. There may be an infinite number of differentiators in R″, as p, p^2, p^3, and so on, where p^n means d^n/dt^n. But there is not a single arbitrary constant involved in $E = R''C$, nor, indeed, anything arbitrary.

Returning to the wires, the form of the resistance operator, as a function of p, depends upon the electrical and geometrical data. It has been determined for round wires and round tubes, and plane sheets. We may take

$$-\frac{dV}{dx} = (R''_1 + R''_2)C + L\dot{C}, \quad . \quad . \quad . \quad (25)$$

as the form of the second circuital law, and make the determination of the operators a matter of separate calculation.

As already mentioned, when C is steady, R''_1 degenerates to R_1 and R''_2 to R_2, the steady resistances (per unit length) of the wires, tubes, rods, or cylinders of any shape that may be employed. At the same time the inertial term disappears. Also, when C varies, it is sometimes sufficient to take into account only the first approximation to the form of the operators. This is, for a solid round wire,

$$R''_1 = R_1 + \tfrac{1}{2}\mu_1 p, \quad . \quad . \quad . \quad . \quad . \quad . \quad (26)$$

and similarly for R''_2. This $\frac{1}{2}\mu_1$ is the value of the steady inductance of the wire, μ_1 being its inductivity. When not solid, or not round, some other expression is required. Notice that this brings (25) to the elementary form (19), because the inductance of the wires may be included in L itself, which then becomes the complete steady inductance (per unit length axially), including that due to the dielectric and that due to the two wires. This usually means only a small increase in the value of L, unless the wires be of iron.

But besides the above simplification, there is an exceedingly important general case in which a similar reduction takes place. This occurs when the sources of disturbance vary simple periodi-

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cally with the time. Then the electric and magnetic fluxes everywhere vary ultimately according to the same law with the same period, provided the relations of the fluxes to the forces are linear; that is, when the conductivity, permittivity, and inductivity, are constants at any one place. Now, when this comes to pass, both E and C in the equation $E = R''C$ vary simple periodically with the time. But when the sine or cosine is differentiated twice, the result is the same function negatived, and with a factor introduced. Thus, if the frequency is $n/2\pi$, so that $\sin(nt+\theta)$ may be considered to be the time-factor in the expression for either E or C, we have the property $d^2/dt^2 = -n^2$. Put, therefore $p^2 = -n^2$ in the expression for the resistance operators, and we reduce them to

$$R''_1 = R'_1 + L'_1 p, \qquad R''_2 = R'_2 + L'_2 p, \quad . \quad . \quad (27)$$

where R' and L' are functions of n^2. They are, therefore, constants at a given frequency, and this is a very valuable property, as it is clear at once that we reduce the equation (25) to the simple form—

$$-\frac{dV}{dx} = (R'_1 + R'_2)\,C + (L + L'_1 + L'_2)\,pC \quad . \quad (28)$$

or, more briefly and clearly,

$$-\frac{dV}{dx} = R'C + L'\dot{C}, \quad . \quad . \quad . \quad . \quad (29)$$

which is the same as (19), valid when the penetration is instantaneous, but with different values of the constants involved. The steady resistance R is replaced by R', the effective resistance (of both tubes per unit length) at the given frequency, and L the steady inductance (inclusive of the parts due to the wires) by L', the effective inductance.

Owing to the reduction of the second circuital equation to the primitive form, we are enabled to express the propagation of simply periodic waves along wires by the same formulæ, whether there be or be not imperfect penetration. We simply employ changed values of the constants, resistance and inductance, which may be independently calculated, or left to the imagination, should the calculation be impracticable. This is, when it can be effected, the best way of making extensions of theory. Do the work in such a way that harmony is produced with the more rudimentary results, and so that they will work together well, and the new appear as natural extensions of the old. An appearance of far greater originality may, indeed, be produced by ignoring the form of the elementary results, but the results would be cumbrous, hard to understand, and unpractical.

The effect of increasing the frequency from zero to a high degree is to first lessen the penetration, and end in mere skin penetration. Consequently, the quantity L', the effective inductance, goes from the full steady value $L + L'_1 + L'_2$, and finishes at L simply, the inductance of the dielectric. But the difference need not be great. In the case of suspended copper telephone wires the inductance of the dielectric is far larger than the rest, so that there is no important variation in the value of the inductance possible, nor would there be were the frequency increased up to that of Hertzian vibrations. But as regards the effective resistance, the case is different. As the distribution of current in a wire changes from that appropriate to the steady state, the resistance increases, and the increase is not always a negligible matter. If long-distance telephony were carried on along iron wires it would be a very important effect. But the Americans, who were the introducers of long-distance telephony, soon found that iron would not do, and that copper would. The reason of the failure is mainly the largely increased resistance of iron. In copper, on the other hand, it is an insensible effect at the lower limit of telephonic frequency of current waves, with the size of wire employed, and is not very important at a frequency three or four times as great. On the other hand, in the numerous experiments with very rapid vibrations of recent years, due to Hertz, Lodge, Tesla, and many others, the increased resistance due to imperfect penetration becomes a very important matter, and is one of the controlling factors that should be constantly borne in mind.

(To be continued.)

THE PRICE OF ELECTRIC SUPPLY.

BY E. TREMLETT CARTER.

In his Presidential Address, before the Junior Engineering Society, on November 4, 1892 (see *The Electrician*, Vol. XXX., page 29), Dr. Hopkinson laid down the principle that "the charge for a service rendered should bear some relation to the cost of rendering it," and showed that the cost of rendering to the public the service of electric supply might be expressed in an equation containing one large *constant* term and one term depending on the amount of energy supplied. As a matter of fact, the cost of producing energy at a station takes the mathematical form—$C = K + k\,Q^n$); where K represents the fixed costs, Q the output, and n is an exponent always less than unity. If the variable charges were simply proportional to the output, n would be unity; but, as a matter of experience, the efficiency of a station falls with the output, owing to the increased consumption of fuel at lower rates of supply. In condensing stations, with a largely sub-divided plant, n would be nearly unity and k would be small; while, with large non-condensing or triple-expansion engines, k would be very much larger, and n would be of the order of 0·5. If we divide C by the output Q, we obtain c, the cost of unit output, and

$$c = \frac{K}{Q} + k\,(Q^{n-1})$$

Thus, if the output of the station is very small, the cost of producing the unit of energy per hour will be enormous; and the curves representing the relation between the costs at different outputs and at different types of stations, will be a series of hyperbolæ, but having different sets of axes. For example, the rectangular hyperbola of the simplest form will occur where n is unity, and will have an asymptote or abscissa k units of length above the zero line of the curve. In all cases the cost, c, will indefinitely approach infinity as the output approaches zero.

In the majority of cases the exponent of efficient generation, n, is practically an indeterminate quantity; but station engineers like to be able to believe that its value lies near enough to unity for the difference to be negligible. At any rate, for simplicity's sake, it will be well to assume that its value is practically unity. The cost of supplying any number of units of energy to a consumer, in any given time, will then become

$$C_1 = K_1 + k\,U$$

where U is the number of units supplied; and K_1 is a constant for fixed charges, depending on the amount of plant involved, and directly proportional to the number of lamps of any given size, and the cost per unit will be

$$c_1 = \frac{K_1}{U} + k.$$

Experience shows that the second or constant term is always smaller than the first or variable term; or, in other words, that there is a rapid rate of decrease in the cost of supplying a unit of energy in proportion as the number of units supplied increases, the supply taking place in any given unit of time. The effect is analogous to the well-known market law—"a reduction on taking a quantity."

This being the state of affairs, electrical engineers who have the management of central-station business have considered whether it would not be advisable to adopt a scale of charges which should run parallel to the curve of costs. The consumer who puts 100 lamps on to his wires, but never uses more than 10 at a time, does not compare favourably with the man who, having 10 lights, uses all of them very frequently. The constants of their two equations are not the same. The former requires the supply undertakers to be ready at any time to supply current for 100 lamps, but never pays for more than 10; so that the undertakers are involved in a high rate of fixed cost, K_1, in his case. The other consumer, having one-tenth of the plant installed, has only one-tenth of the constant for fixed charges; he therefore costs the undertakers less for every unit he consumes in the given period. It is important to notice that *the cost of supply does not so much depend on the maximum number of lamps used in the stated*

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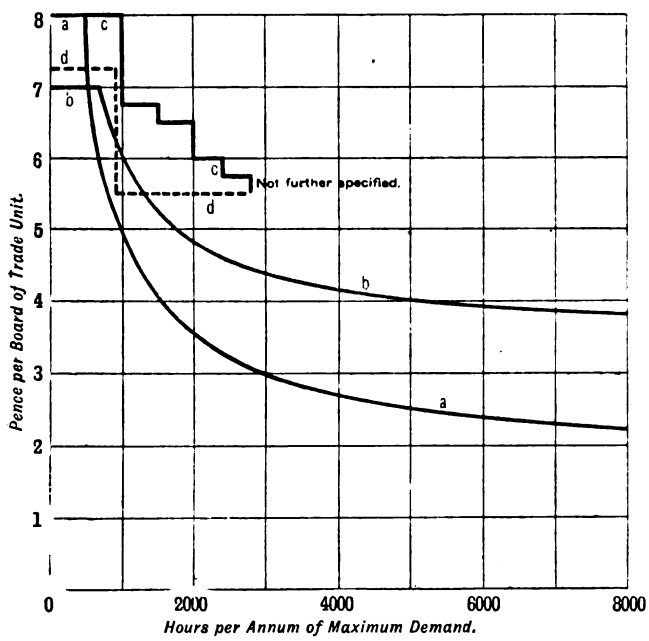
period as on the maximum number which might be used, together with the number of units of energy actually consumed. For the amount of plant which the supply undertakers must hold in readiness against any given house circuit depends only on the number of lamps which can be used on that circuit. It may happen that a whole year may pass before they *are* all used, and during that entire year the fraction of the generating plant which they represent will to a great extent have been unpaid for, unless the charges are based upon the total number of lamps wired. We are not now concerned with the policy of adopting such a scale of charges, but merely with the fact that, for the charges to be parallel with the costs, such a scale is necessary.

The system of charging for energy, proposed by Dr. Hopkinson, and known as the "Manchester" system, is one which approximately follows the scientific lines referred to in the foregoing paragraph. It arranges that "for each unit per hour in the maximum power demanded, a charge not exceeding £3 per quarter, and in addition for each unit supplied, a charge not exceeding twopence," shall be made. If the maximum power demanded is based upon the total number of lamps wired, the system becomes perfectly scientific; but it is contended that this would introduce objectionable features, as will presently be seen. As a matter of fact, it has been proposed to employ a



(*a.*) Manchester. (*b.*) Brighton. (*c.*) Leeds. (*d.*) Metropolitan Co.

maximum recording ammeter, by means of which the maximum demand during the quarter can be determined. In the accompanying diagram it will be seen that the charges on the "Manchester" system (curve *a*) represent 8d. per unit if the supply is taken for less than 500 hours per annum. In other words, if the lamp-hourage is not equivalent to more than the maximum demand lasting 500 hours this full charge will be made. To obtain energy at 4d. per unit the maximum demanded supply must be kept up for 1,500 hours, or there must be an equivalent consumption. Thus, suppose the maximum demand to be 100 lamps, then there must be at least 150,000 lamp-hours used in the year. This is equivalent to running the full demanded current through the circuit from dusk till about 10 p.m. every day in the year.

The "Brighton" system, introduced by Mr. Arthur Wright, is one which possesses many interesting features, and nearly the same defects as the system we have just considered. This method of charging is now in use at the supply station of the Brighton Corporation. It is designed as follows:—A charge of 7d. per unit demanded for the first two hours every day, and 3½d. for each additional unit consumed. The maximum number of units demanded is obtained by means of a maximum recording ammeter, the readings of which are taken during the three darkest months in each half-year. The average of the readings in any one half-year is considered to be the maximum demand. Thus, if P is the maximum demanded power in kilowatts, and U is the number of units consumed in the average twenty-four hours (as determined by the meter), then the daily duration of the maximum demand is U/P. The excess of this over two hours gives the time during which the lower scale of charges is being made. For example, if U is twice P, there is no excess, and the full charge will be made for every unit; if U is 2·8 P, the price of each unit throughout becomes 6d.; while, to bring the price down to 4d. per unit, the maximum demand must be kept up for fourteen hours per day. Finally, if the maximum demand is maintained continuously during the whole of every day (twenty-four hours), the price of each unit consumed reaches its lowest limit of 3·83d. A comparison of this system with the "Manchester" system may be made by comparing curves *b* with *a*. In curve *b* the "Brighton" system has been reduced to the same scale of measurement as in *a*, namely, the number of hours in the year during which the maximum demand is used and the price per unit for abscissæ and ordinates respectively.

Now as to the defects of these two systems. The most obvious fault in them is the fact that they do not really charge the consumer for what he may at any moment demand; they merely charge according to what he may have demanded in the particular quarter or half-year in which the bill is drawn up. For example, suppose two separate consumers have, the one 1,000 lamps and the other 100; and that they both manage to keep the maximum number of lights on at any one time as low as 50. Let us further suppose that each of these consumers takes exactly the same number of units through the meter in the stated time. Then, on either of these systems, each of the two consumers would have to pay exactly the same amount of money. Obviously, this is not what the financial conditions require. The larger householder is a greater burden to the supply undertakers; for he may, at any time, put the whole of his lights on the circuit. Not till he does so, however, will he pay a penny for the privilege of having them wired. It has been urged that to estimate the maximum demand on the basis of the number of lamps wired would discourage the wiring of occasional and unimportant lamps; while these are often of great service to the supply undertakers, because they are most frequently used at times when other lamps are not in use. Another defect lies in the fact that if the consumer gives two big parties in one quarter or half-year, and none at all in the next, he does not pay so heavily as if he gives a party in each separate period; while he is equally a burden on the station in the former as in the latter case. A last defect is that neither of these systems encourages the consumer to take his energy at a time when the supply people would prefer that he should do so. This last requirement arises from the fact of the exponent not being exactly unity; in other words, it is due to the fact that the supply people can afford to pay something to encourage a consumer to take current when their station is running at a low load. Now, neither of these systems offer energy at a cheaper rate during the hours when the station can spare it better than during the few hours when it is pressed with customers. It is true that they induce the customer to stay a long while on the mains, but they do not induce him to put his load by preference on the mains during daylight hours rather than during hours from dusk till 8 or 9 p.m.

Such an inducement is offered by the method of differential charges in use on the St. Pancras mains. From this station, energy can be obtained for 3d. per unit for power alone, but for not less than 6d. per unit for power and light or for light alone. In the daytime, therefore, energy will cost only 3d.; while at night, unless it be used for power alone, it will cost 6d. This is effected by providing the power-and-light customer with a two-way switch, by means of which he may put on the current through his motor alone at the lower price, the current passing through one meter; or he may send the current through another meter to the lamps and motor, or the lamps alone. The chief defect of this system is that it encourages the consumer of electricity for large amounts of motive power to burn gas instead of electric light, if he desires to do work in the night; for, if he puts in electric light, he will pay for all the night work at the higher rate.

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In addition to these systems, it has been proposed to employ meters which shall be automatically switched on to a different rate of indication at different times of the day. Mr. Kapp proposes to have a clock which should shunt a varying fraction of the current through the meter, a large fraction going through when a high rate of charge is to be made, and a less fraction when energy can be supplied cheaper. Others have proposed to graduate the meter to register, not electricity, but £. s. d. on a variable rate of charging. The defects in these systems arise from the uncertainty of the mechanism and the impossibility of calibrating it. The machinery of the "Leeds" system of charging is entirely financial. In this system, the customer is granted a rebate on the principle of trade discounts. He is expected to declare what maximum supply he will require, and will be charged according to the following plan :—The full price of 8d. for the maximum supply extending over less than 250 hours ; 10 per cent. discount on the full price if the consumption reaches 250 hours, 15 per cent. if it reaches 375 hours, and so on. The number of hours is reckoned per quarter, so that a large consumption of energy per lamp is expected before any rebate is granted. Curve *c* shows the scale of charges on the "Leeds" system. It may be remarked that the proposal to limit the consumer to the actual maximum supply demanded, by putting into his main fuses of such a size that fusion will take place if he exceeds it, is one which cannot be tolerated. Such a system takes no account of the necessary factor of safety for fuses, and would bring the fuses to the very point of melting at each time that the maximum demanded supply was being taken. Another defect in the "Leeds" system is the lengthy period over which the lamps must be used before any rebate is given, the full price being charged unless the consumption exceeds 1,000 hours per annum, or nearly three hours per day. Business houses using the light on six days in the week, would require to burn the maximum number from sunset till a quarter-past nine every evening to get the 10 per cent. rebate ; and till half-past 12 a.m. to get the 20 per cent. rebate. Most shops, many private houses, and all churches, would be excluded from any discount whatever ; and being charged a very high rate for supply, would be induced to adopt gas or some other illuminant. If the "Leeds" system were based upon the number of lamps wired, and the periods before the successive discounts come into operation were shortened, it would constitute one which would have the great merit of treating small consumers on as favourable a footing as large ones. Apart from this, however, it possesses all the defects of the "Brighton" and "Manchester" systems. The scale of charges adopted by the Metropolitan Electric Supply Company is based upon the total number of lamps *wired*, the customer being charged at a rate which depends upon the quarterly consumption *per lamp on his circuit*. The details of the method are : A price of 7¼d. is charged for all supply up to 8 units per quarter per 35-watt lamp wired, and the lesser price of 5½d. is charged for each additional unit. Collating this with the other scales, at so much per annum, we arrive at curve *d*. Up to 32 units per annum per lamp the price is 7¼d. per unit, or £1 per lamp ; and this requires each lamp to be run for about 900 hours per annum, or three hours per working day. Every lamp must, therefore, be alight from dusk till 9 p.m. throughout the year before the lower tariff is reached. The direct effect of this will be to eliminate unnecessary, or hardly necessary, lamps, as will be seen by the following comparison between two circuits :— In the first circuit let there be 20 lamps, which will all be used nightly from dusk till midnight ; in the second circuit let there be 20 lamps as above, and 10 lamps which are only turned on for an average of a minute or two per diem. What are the respective annual bills for these circuits ? That for the first will be £1. 15s. 6d. per lamp, or £35. 10s. for the set ; the second bill will be £1. 8s. per lamp, or £42 for the set of 30 lamps. The 10 idle lamps together cost £6. 10s., or, separately, about 13s. per annum, for the privilege of having them wired. This system favours the small consumer, in so far as he is (electrically) an industrious one, but the tariff is not so attractive to the general consumer as that offered either at Manchester or at Brighton.

The objection has been raised to the method of charging according to the number of lamps *wired*, that the consumer can easily substitute 16 c.p. or even higher-power lamps for 8's. As a matter of fact, however, this constitutes no obstacle in the way of adopting this system. The addition of a maximum recording ammeter is all that is necessary. Suppose a consumer puts in 100 lamps of 8 c.p. Let him be charged on the basis of this number of lamps, *as long as the current he uses does not exceed that required for this number of lamps*. And, if he chooses to substitute 16-c.p. lamps for the 8's, then, as long as he never takes more current than would be required for the 100 former sized lamps, he does the supply undertakers no injury. On the other hand, if he puts into circuit so many 16's that more current than the 100 8's is taken, the recording ammeter will tell its little story. If he did that, the recorded current on the instrument might be made the basis of charge ; or, better still, to act as a deterrent, he might be charged the full 8d. a unit for every unit passed through his meter. If consumers understood that this would be done, they would not put larger lamps in place of small ones. As regards the inducements which should be offered to consumers to fill up the day load, which is a very much more serious matter, we would suggest the following plan. Let every consumer whose consumption is so large that he can afford to pay a little higher rental for the meter, if thereby he can get energy during the day at a cheap rate, be provided with a single meter of the following description :—The meter will be of the ordinary type, except in so far that it will be provided with two sets of counting wheels and dials. One set will register energy during the day, and the other set during the night, both being actuated by the same mechanism. At times, which shall be determined upon by the supply undertakers, the one set will be automatically disconnected from the gearing, and will be locked ; at the same time the other set of counting wheels will be thrown into gear. Mechanism for doing this would be very simple, and not likely to get out of order. In order to determine with great accuracy the successive periods during which the sets would be alternately in gear, a clock, provided with a simple electro-motor and set of contacts, would be necessary. This clock might be automatically wound up by means of the motor, or it might be kept in synchronism with a station clock, and would thus supply the customers with Greenwich time. The function of the motor would be to throw over the couplings for the sets of counting wheels from time to time. In addition, a simple galvanoscope in the front of the meter might be made to indicate whether the higher or lower rate of charge was being made, by pointing to the right or to the left. The entire additional mechanism would not cost more than would be covered by an additional few shillings on the annual meter rental ; and, though it would not pay the small consumer of lamps, it would undoubtedly furnish an attractive tariff to the large consumer of lamp and motor-power.

BOOK RECEIVED.

"Summary of the Factory and Workshop Acts." By Emile Garcke and J. M. Fells. (London : Crosby Lockwood and Co.) Price 6d.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, June 9th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read : (1) "A New Photometer," by A. P. Trotter ; (2) "Notes on Photometry," by Prof. S. P. Thompson, F.R.S. ; (3) "The Magnetic Field Near a Wire," by Prof. M. Minchin, M.A.

ROYAL INSTITUTION.

9 p.m. Evening Discourse : "The Recent Solar Eclipse," by Prof. T. E. Thorpe, F.R.S.

THURSDAY, June 15th.

CHEMICAL SOCIETY.

8 p.m. Papers to be read.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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Editorial, Publishing, and Printing Offices :
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STEEL-PLATE PORTRAITS

Of Willoughby Smith; W. H. Preece, F.R.S. (President of the Institution of Electrical Engineers); Michael Faraday; Sir John Pender, G.C.M.G., M.P.; Sir William Thomson, F.R.S. (Lord Kelvin); C. H. B. Patey, C.B.; Dr. John Hopkinson, F.R.S.; Dr. Oliver J. Lodge, F.R.S.; Prof. William Crookes, F.R.S.; Prof. von Helmholtz; Prof. W. E. Ayrton; Lord Rayleigh, F.R.S.; Cyrus W. Field; Werner von Siemens; and Sir James Anderson, have been issued as Supplements to "THE ELECTRICIAN."

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ELECTROSTATIC VOLTMETERS.

It is tolerably safe to say that COULOMB made the first electrostatic voltmeter, as distinguished from the electroscopes of gold leaf and of pith balls. In making this statement we, at all events, run no risk of an indignant letter from a prior inventor. For laboratory work the quadrant electrometer and the highly-developed guard-ring electrometers of Lord KELVIN have satisfied all requirements, and multicellular and other forms have been offered for commercial use. Mr. A. WRIGHT, of Brighton, was one of the first, if not the very first, to use an electrostatic direct-reading voltmeter for daily use in the engine room of a central station. This he did some six years ago, and his instrument was described in *The Electrician*, Vol. XX., p. 153. There was no distinct demand for electrostatic voltmeters until the high voltages of alternate-current supply became general. Excellent electro-magnetic voltmeters had by this time been so designed that temperature errors were eliminated, and unlike the early voltmeters they could be left always in circuit. The Cardew voltmeter had also arrived at a high degree of accuracy, but for measuring 1,000 or 2,000 volts it was necessary either to use a transformer to bring down the pressure to 100 volts or so, or to put a large resistance in series. Little transformers are troublesome to make and likely to break down, and their transforming ratio cannot be relied upon, whilst the large resistance plan entails a great expenditure of power. A Cardew voltmeter, with the necessary resistance, takes 1 H.P. at 2,200 volts. Mr. SWINBURNE pointed out in his Paper on "Electrical Measuring Instruments," read before

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the Institution of Civil Engineers last year, that each watt lost in an instrument constantly in use was equivalent to the interest on £1. Messrs. Swinburne and Co. were one of the first to offer substantial and accurate electrostatic voltmeters, some with suspension for laboratory work, and others constructed in a style suitable for the requirements of the switch-board of a central station. Four Swinburne electrostatic voltmeters of the laboratory type were used by Dr. Fleming in his recent exhaustive researches on transformers, and he found no difficulty in reading to about one-quarter per cent., a difference of three or four volts in 2,400 being easily detected. The only defect pointed out by Dr. Fleming was the large moment of inertia of the needles and the absence of a suitable damping arrangement. On December 2, 1892, during the discussion on Dr. Fleming's Paper, we published a brief account of recent improvements which had been made in these instruments. An oil damper had been added, and it was claimed that with a steady pressure the instrument might be read to half a volt in 2,000.

The quadrant electrometer, from which most electrostatic voltmeters have been developed, was provided with a "needle" having a considerable moment of inertia. In constructing a sensitive instrument, under conditions which preclude the use of fine suspension fibres, the use of a large "needle" introduces difficulties. Lord Kelvin has met this in his multicellular voltmeter by the use of a number of small needles, and Prof. Ayrton and Mr. Mather have abandoned the flat form, and have used curved plates, giving a large surface, but keeping down the moment of inertia. The working parts of the instrument, which we briefly describe in another column, has a curious but accidental resemblance to those of the Hartmann and Braun electromagnetic instruments, which are mere modifications of the well-known Evershed gravity instruments. As in the Evershed instrument, by different shaping of the parts, any desired arrangement of scale may be obtained. For laboratory work "dead-beatness" is very desirable, if only for saving time, but it is by no means so important for switch-board work. "Dead-beatness" is an awkward term, and to say that one instrument is "rather dead-beat," and that another is "very dead-beat" shows a ridiculous poverty of language. The literal equivalent "thanatotyptic" does not help us much. Fortunately there is but little need for it. What is meant by a very dead-beat instrument is that it is well damped. If it is so well damped that the index does not overshoot the mark it is said to be aperiodic. The term "dead-beat" is often used as if it had something to do with a slow period. It would be better to restrict it to mean that a short space of time elapses between the starting of the index, say, from zero, and its final arrival at its destination. For switch-board use a slow period is rather an advantage, and the expanding of the scale at the working part should receive more attention than has been given to it. For laboratory purposes a more or less evenly divided scale may be useful, but to use such a scale for a switchboard, if an expanded scale is possible, is to make a large sacrifice in sensitiveness.

Electrostatic instruments perhaps fail to inspire such confidence as has been placed, and too often misplaced, in electromagnetic instruments. In the latter, two or three hundred ampere-turns are fixed once and for all to give the directive force, and gravity or a spring gives the control. The coils are not likely to alter, and the iron cores or armatures, though they are to blame for most of the errors, can only be injured in so far as they may become displaced with reference to the pointer. But electrostatic instruments, containing, as they do, thin sheets of metal, subject to very small forces, must be provided with very delicate pivotting, and any bending or displacement of the "needles" is likely to give rise to serious errors. Internal sparking must be guarded against, and for low voltages contact difference between different metals, and even the degree of oxidation of the surfaces, must be allowed for. For voltages between 300 and 30,000, electrostatic voltmeters will hold their own. For lower pressures there is no apparent advantage, excepting, of course, those laboratory purposes for which electrometers are preferable. For very high voltages, such as are used in Teslaic experiments, electrostatic voltmeters become filled with brush discharges, but even if the whole of the working parts were immersed in oil, as has been done by Mr. Swinburne, they would not give any useful indication when interrupted currents and high-frequency discharges are used. For such researches an altogether new voltmeter has yet to be invented.

REVIEWS.

Dynamos, Alternators, and Transformers. By Gisbert Kapp, M.Inst.C.E., M.Inst.E.E. Illustrated. (London: Biggs and Co.)

In the preface the author states his object to be an exposition of the general principles of the construction of dynamo-electric apparatus, without the use of high mathematics and complicated methods of investigation, so that the average engineering student and the average practical engineer, *even if he have no previous knowledge of electrical science* (the italics are ours), can follow the subject. We sincerely hope both may be able to follow Mr. Kapp's admirable treatment of the matter, but we doubt it.

It is not easy for the author to "put himself in the place" of the average engineer who has simply mastered sufficient of the theory of electro-dynamics to couple-up and run a dynamo, and to make a few elementary calculations with reference to its output.

Mr. Kapp's new work is a fitting sequel to the various text-books. But, like all books that treat on subjects of large capacity and daily growth, it attempts too much, and consequently represents thoroughly but few of the many sides of the question, and necessarily assumes a closer acquaintance with elementary and fundamental facts than the average reader can possibly possess.

We find the index to be incomplete, and the sub-divisions of the chapters having no distinctive numbers, it is difficult to collect the references to any particular part of the subject. The utility of the book would be largely increased by a synopsis of the symbols and their meanings; as it is, we find it difficult to follow many of the equations.

In the first five chapters Mr. Kapp treats of the elementary conceptions of a magnetic field, and by a gradual transition leads up to the magnetic circuit of the dynamo. It is scarcely to be expected that an author can now-a-days find novel ways of dealing with this branch of the subject. Mr. Kapp lays some stress on the analogy of magnetism to a fluid, and the parallel certainly helps to explain the phenomena, and gives a physical interpretation to the equation of much value to the practical man. We also agree with the author that the term magnetic resistance is a most convenient one, and, used with the reservations he has made, it is of use in designing dynamo magnetic machinery. Much of the mathematics used in this portion of the book is, however, of a character better suited to text-books on magnetism, and, we fear, will have little attraction for the class of reader mentioned in the preface.

In Chapter VI. the magnetic properties of iron are discussed, and the terms hysteresis, permeability, and coercive force are elucidated both by mathematics and numerical examples. Chapter VII. brings us into touch with practice with the determination of the electromotive force, and the general question of armature-winding and pressure is enlarged upon in the next two chapters. This portion of

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the book contains practical information with reference to bipolar and multipolar winding. The winding and potential-difference tables are new, and will certainly prove to be interesting to dynamo constructors. The various methods of avoiding the contiguity of wires at widely different pressures, though probably known to most machine constructors, are certainly not much practised, and yet they are worthy of special study. Field-magnets, determination of exciting power, and predetermination of characteristics, form the subject-matter for Chapter X. These questions have been treated in detail by various writers, and no doubt exception will be taken to much that the author says. The shape of a field-magnet is very much a matter of fancy on the part of the designer, and the accuracy of the predetermination of the "curve" depends very largely on his ability to make *scientific guesses* at certain coefficients and on a happy balancing of a number of factors, easy to settle on paper but difficult to control in the works. His expedient of showing at a glance the weight of copper in the windings by the depth of the black sections in the drawings is a useful device.

In Chapter XI. reference is made to the conditions necessary to secure a sparkless collection or commutation of current, and, as a necessary consequence, the back and cross turns of the armature are discussed, and a formula, for the "armature back ampere-turns" is given in this form, $X_b = \tau c \frac{a}{\pi}$; where τ = the number of conductors counted all round, c = the current in one conductor, and a = the angle of lead. And this is stated to be applicable to bipolar and multipolar machines; but the reader is left in doubt as to whether the Gramme and drum windings require the same compensating excitation. The equation, as it stands, appears to us to be approximately true for Grammes, but for drums we think it would be more nearly correct if the denominator were multiplied by two. And in both cases should not the equation be multiplied by the coefficient of magnetic leakage for full excitation?

A chapter is next devoted to the consideration of the influence of linear dimensions on the output, and the "critical" conditions of small and large dynamos. For the same efficiency the output of the larger machine will vary as the third power of the linear dimensions; for the same heating as the 5/2 power, and for the same sparking as the square. In criticising these statements, it should be noticed that they are true only when the two machines are identical in type and differ simply in size. The author also touches on the interesting question of losses in dynamos, and gives an experimental method of finding the power consumed by hysteresis, friction, and eddy currents at light and full load. Chapter XIV. is disappointing in some respects. It purports to give examples of dynamos in the market to-day, and we find the well-known and widely-built under-type two-pole drum dynamo illustrated by the machine of a firm scarcely known as builders of dynamos. We have nothing to say against the dynamo in question, but it cannot be said to be that of a representative constructor. The points of the over-type drum-armature class are shown by reference to one of Johnson and Phillips's "Kapp" dynamos. And the large, slow-speed, multipolar, Continental type is illustrated by one of the latest Oerlikon dynamos with a vertical shaft. And then follows a list of dynamos shown at the Crystal Palace last summer. The weak point about information derived from manufacturers at Exhibition times, when visions of gold medals are in the air, is that the coefficient of "errors in judgment" needs considerable correction.

In the next chapter the alternator is discussed in theory and practice. Electromotive force and other fundamental calculations are made without a very apparent use of sine functions, which will be a welcome addition to the practical literature of the subject. The effects of the "pitch ratio" of pole-pieces and armature coils is also fully discussed, for at least one case, and the constants for the more general designs are tabulated on page 374. Armature self-induction calculations are referred to in a simple manner, and it appears that the determination of the coefficient L (*i.e.*, the product of the square of the number of turns and the magnetic flux) is a very easy matter. Yet L is not a constant, but varies with the position of the coils; and although the limits of its values may not differ much in some machines, they appear to do so in others. We submit, then, our doubts as to the practical value of Mr. Kapp's equation for finding L in terms of the effective electromotive force of self-induction and the frequency and the effective current. The equation in practical units is given as follows:—

$$e = 2\pi n L i \quad . \quad . \quad . \quad . \quad . \quad . \quad (53).$$

It is obvious that L has a different value for different positions of the armature.

On page 387 Mr. Kapp discusses the "conditions for maximum power" in a given circuit, and states that these are satisfied when the pressure lost over the ohmic resistance is equal to the pressure of self-induction, and that they correspond to an angle of lag of 45deg. between the effective impressed pressure and the effective current. He concludes, if we understand him rightly, that an alternating motor must have a definite virtual resistance, and its self-induction must have a certain value in order to develop maximum power. And assuming the ohmic resistance of a given motor to be negligible compared with the self-induction, he states that the desired end is attained when the pressure required to overcome its self-induction equals the pressure required to overcome its counter electromotive force. It follows from this, he continues, that low frequencies are essential if the condition of maximum power is to be even approached. This investigation is of importance in connection with the alternate-motor question, and especially in reference to self-starting single-phase machines. In Chapter XVI. the effects of self-induction and capacity are illustrated both analytically and graphically, the equations being in practical units and free from trigonometrical functions, and the statics by Blakesley's well-known clock diagrams.

Parallel running is fully investigated, and the various problems likely to occur in practice. Then follow five interesting diagrams, all referring to parallel working, and showing the relations between armature and omnibus-bar pressures; and, finally, the necessity for regulation by adjustments of the driving power, and not by means of the excitation, is arrived at.

Mr. Kapp has investigated the effect of armature reactions in alternators, and arrives at the following equation for the value of the back ampere-turns:—

$$X_b = 0{\cdot}0156\, w\, i\, \phi \quad . \quad . \quad . \quad . \quad . \quad (59).$$

Where w is the number of active wires in one coil, i is the effective current, and ϕ is the angle of lag. The coefficient has been determined for a pitch ratio, in which poles, spaces, and coils are of equal width. The equation is evidently of the right order, for the reactions must vary with the current i, and with some function of the lag; but since these two terms vary inversely, the demagnetising effect may within wide limits be sensibly constant. Hence, although an alternator does not *necessarily* require compound coils, yet the ampere-turns necessary for the open-circuit pressure must be increased or diminished according as the armature current lags or leads. Mr. Kapp insists on "a reasonable amount of self-induction" as an essential in a good alternator for parallel running.

The conditions of stability of working, as generator or motor, are next elucidated in a series of intricate problems illustrated by diagrams. The effects of lead and lag in determining the range within which a given machine may be safely worked in either of those conditions is finally shown in Fig. 112. This part of the book is full of interesting matter, and several of the imperfectly understood phenomena occurring in practice, are, if not thoroughly explained, at any rate, considerably simplified. Amongst others the apparently singular fact that two alternators of widely differing open circuit pressures may be coupled in parallel, and will then run at a terminal pressure approximately equal to the arithmetical mean between the two open-circuit pressures. The general conclusions at the end of this section summarise the known facts of alternate-current working. These are, of course, recognised by most of the more prominent electrical engineers; but some of Mr. Kapp's deductions will be challenged, and some of his theories will be attacked. This is to be expected.

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The next chapter is devoted to transformers. It necessarily suffers somewhat by comparison with Dr. Fleming's recent work on the same subject, but, nevertheless, forms a short pithy statement of theory, and most of the practical conditions of working are discussed and their graphical treatment suggested by clock diagrams. The effects of self-induction and capacity on the voltage drop and the importance of restricting the magnetising currents within small limits are abundantly shown. The final chapter is a *résumé* of the better-known alternators, and forms a fitting conclusion to the book.

"Dynamos, Alternators, and Transformers" is a book that will be invaluable to the advanced student and the dynamo-designer, but we fear it will prove too difficult reading for the average engineer. There are a few misprints, chiefly in equations; but they are obviously printers' errors, and the corrections are apparent. A. T. S.

AYRTON AND MATHER'S ELECTROSTATIC VOLTMETER.

An electrostatic voltmeter designed by Prof. Ayrton and Mr. T. Mather, and made by Mr. R. W. Paul, is shown in Fig. 1.

FIG. 1.

The working parts of the instrument are shown diagrammatically in Fig. 2. The parts A, B, C, are the fixed inductors, corresponding to the quadrants of an electrometer. These inductors are curved brass plates, the edges and corners being carefully rounded to prevent sparking. They are connected

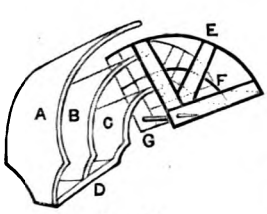

FIG. 2.

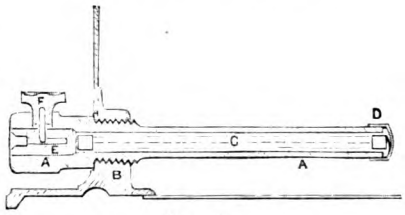

FIG. 3.

together by the plate D. The "needle," E, F, consists of two thin curved aluminium plates, concentric with the staff G, which carries them. These plates are drawn into the space between the inductors by the electrostatic attraction between them, and are counterpoised by the hand and controlled by a weight attached to an arm on the staff so as to bring the hand to zero. Their moment of inertia is so small that the needle takes its position of equilibrium rapidly. The dial is supported on ebonite pillars, and surrounded by a bezel ring of ebonite, which prevents contact with the outer case; the latter is, therefore, entirely insulated from the circuit. Each terminal, of which a section is shown in Fig. 3, is cased in ebonite, so that a person connecting up cannot receive a shock from it. The hollow ebonite portion, A, A, contains a brass block E embedded near its outer end, and covered by an ebonite nipple; the block is tapped for the set screw F, which holds the wire in place. The part of A which projects into the case, into which it screws at B, contains a fuse of platinum silver 0·001in. diameter, enclosed in a glass tube with metal caps, to which it is connected. They make contact with the block E at one end, and the spring cap D at the other. The cap D makes contact in turn with the connecting spring mentioned above. The fuses are therefore very easily replaced. A spark-gap is arranged inside the voltmeter, and is adjusted so that, in case of abnormal rise of pressure, sparking will occur at the gap and produce no damage. The scale has a movable index and has a radius of 6in. and a length of 10in. The instruments at present made are suitable for circuits at 500, 1,000, 2,000, and 2,400 volts.

THE FORTHCOMING INTERNATIONAL ELECTRICAL CONGRESS AT CHICAGO.

The following is a *résumé* of the preliminary programme of the International Electrical Congress to be held in Chicago in August:—

On Monday, August 21st, at 3 p.m., the Opening Session of the General Congress will be held, and permanent officers, &c., will be nominated. At the close of this meeting the Chamber of Delegates will assemble for preliminary organisation. The Chamber of Delegates will consist of the official delegates from the various Governments.

The General Congress will be divided into three sections, as follows:—(A) Section of Pure Theory. (B) Section of Theory and Practice. (C) Section of Pure Practice. These sections will meet for organisation and work at 10 a.m. on Tuesday, August 22nd. Temporary presiding officers will be as follows:—Section A, Prof. H. A. Rowland; Section B, Prof. Charles R. Cross; Section C, Prof. A. Graham Bell. These sections will meet at 10 a.m. on Tuesday, Wednesday, Thursday, and Friday, continuiug in session at will, except on Friday, when they will finally adjourn as Sections not later than 1 p.m. Each Section will have authority to divide into sub-sections if it is thought to be desirable.

At the meetings of these sections, Papers will be read, followed by discussions.* The Papers should be sent to the Chairman of the Programme Committee, Prof. T. C. Mendenhall, Washington, D.C., not later than August 1, 1893. Such as are accepted by that Committee will be put upon the programme of the Congress, to be presented in full or by abstract according to the time available.

The following topics will be considered by the Chamber of Delegates:—Adoption of definitions and values of fundamental units of resistance, current and electromotive force.—Adoption of definitions and values of magnetic units.—Adoption of definition and value of the unit of self-induction.—Definitions and values of light, energy, and other units.—The standardisation of electric lights.—The consideration of an international system of notation and conventional symbols, and of a more uniform and accurate use of terms and phrases in electrical literature.—A commercial standard of copper resistance.

The hours of meeting for the Chamber of Delegates will be determined, after the first session, by the Chamber itself; and it will also decide upon the admission of persons not delegates to its sittings. It will finally adjourn, not later than 1 p.m. on Friday, August 25th, and at the last meeting of the General Congress, the officers of the Chamber will report to it a summary of its proceedings and the conclusions reached.

The General Congress will assemble to hear reports and for final adjournment at 3 p.m., Friday, August 25th.

* The subjects, upon which Papers are solicited, will be found on page 215 of our issue of December 23, 1892.—ED. *E.*

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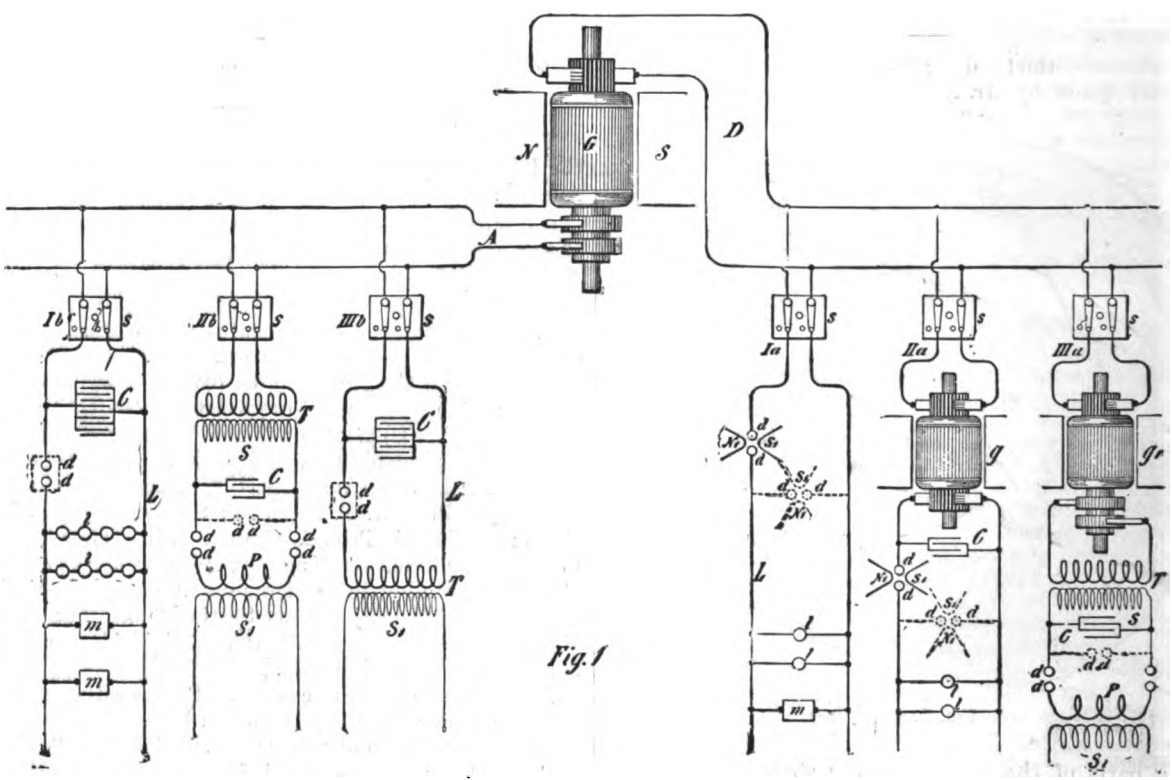
ON LIGHT AND OTHER HIGH-FREQUENCY PHENOMENA.*

BY NIKOLA TESLA.

A number of ways, as practised in the laboratory, of obtaining high-frequency currents either from continuous or low-frequency alternating currents are diagrammatically indicated in Fig. 1, which will be later described in detail. The general plan is to charge condensers, from a direct or alternate-current source, preferably of high-tension, and to discharge them disruptively while observing well-known conditions necessary to maintain the oscillations of the current. In view of the general interest taken in high-frequency currents and effects producible by them, it seems to me advisable to dwell at some length upon this method of conversion. In order to give you a clear idea of the action, I will suppose that a continuous-current generator is employed, which is often very convenient. It is desirable that the generator should possess such high tension as to be able to break through a small air-space. If this is not the case, then auxiliary means have to be resorted to, some of which will be indicated subsequently. When the condensers are charged to a certain potential, the air or insulating space gives way and a disruptive discharge occurs. There is then a sudden rush of current, and generally a large portion of the accumulated electrical energy spends itself. The condensers are thereupon



Plan of Connections Used in the Conversion by Means of the Disruptive Arc Discharge.

quickly charged, and the same process is repeated in more or less rapid succession. To produce such sudden rushes of current it is necessary to observe certain conditions. If the rate at which the condensers are discharged is the same as that at which they are charged, then, clearly, in the assumed case the condensers do not come into play. If the rate of discharge be smaller than the rate of charging, then, again, the condensers cannot play an important part. But if, on the contrary, the rate of discharging is greater than that of charging, then a succession of rushes of current is obtained.

A form of discharger with a magnet which has been found convenient, and adopted after some trials, in the conversion of direct currents particularly, is illustrated in Fig. 2. N S are the pole-pieces of a very strong magnet which is excited by a coil C. The pole-pieces are slotted for adjustment and can be fastened in any position by screws s_1 s_1. The discharge rods d d_1 thinned down on the ends in order to allow a closer approach of the magnetic pole-pieces, pass through the columns of brass b b_1, and are fastened in position by screws s_2 s_2. Springs r r_1 and collars c c_1 are slipped on the rods, the latter serving to set the points of the rods at a certain suitable distance by means of screws s_3 s_3, and the former to draw the points apart. When it is desired to start the arc, one of the hard rubber handles h h_1 is tapped quickly with the hand, whereby the points of the rods are brought in contact, but are instantly separated by the springs r r_1. Such an arrangement has been found to be often necessary, namely, in cases when the E.M.F. was not large enough to cause the discharge to break through the gap, and also when it was desirable to avoid short circuiting of the generator by the metallic contact of the rods. The rapidity of the interruptions of the current with a magnet depends on the intensity of the magnetic field and on the potential difference at the ends of the arc.

When the current through the gap is comparatively large, it is of advantage to slip on the points of the discharge rods pieces of very hard carbon and let the arc play between the carbon pieces. This preserves the rods and besides has the advantage of keeping the air-space hotter, as the heat is not conducted away as quickly through the carbons, and the result is that a smaller E.M.F. in the arc gap is required to maintain a succession of discharges.

In another form of discharger the discharge rods pass through perforations in a wooden box, which is thickly coated with mica on the inside. The spark-gap is warmed by a small lamp contained in the box. The air being warmed to a certain temperature has its insulating power impaired, it becomes dielectrically weak, as it were, and the consequence is that the arc can be established at much greater distance. The air should, of course, be sufficiently insulating to allow the discharge to pass through the gap *disruptively*. The arc formed under such conditions, when long, may be made extremely sensitive, and the weak draught through the lamp chimney is quite sufficient to produce rapid interruptions. The adjustment is made by regulating the temperature and velocity of the draught.

It should be remarked here that when such, or interrupting devices of any kind, are used and the currents are passed through the primary of a disruptive discharge coil, it is not, as a rule, of advantage to produce a number of interruptions of the current per second greater than the natural frequency of vibration of the dynamo supply circuit, which is ordinarily small.

The ideal medium for a discharge gap should only *crack*, and the ideal electrode should be of some material which cannot be disintegrated. With small currents through the gap it is best to employ aluminum, but not when the currents are large. The disruptive break in the air, or more or less in any ordinary medium, is not of the nature of a crack, but it is rather comparable to the piercing of innumerable bullets through a mass offering great frictional resistance to the motion of the bullets, this involving considerable loss of energy. As a medium for the discharge space a solid, or even a liquid, would be preferable therefore. It is somewhat difficult to conceive of a solid body which would possess the property of closing instantly after it has been cracked. But a liquid, especially under great pressure, behaves practically like a

* Abstract of a lecture delivered before the Franklin Institute, at Philadelphia, February 24, 1893, and before the National Electric Light Association, at St. Louis, Mo., March 1, 1893. We are indebted to the *Electrical World*, of New York, for the blocks illustrating this lecture.

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solid, while it possesses the property of closing the crack. Hence it was thought that a liquid insulator might be more suitable as a dielectric than air. Following out this idea, a number of different forms of dischargers in which a variety of such insulators sometimes under great pressure were employed, have been experimented upon. It is thought sufficient to dwell, in a few words, upon one of the forms experimented upon. One of these dischargers is illustrated in Figs. 4*a* and 4*b*.

A hollow metal pulley, P (Fig. 4*a*), was fastened upon an arbor, *a*, which by suitable means was rotated at a considerable speed. In the inside of the pulley, but disconnected from the same, was supported a thin disc h_1 (which is shown thick for the sake of clearness) of hard rubber, in which there were embedded two metal segments, *s s*, with metallic extensions, *e e*, into which were screwed conducting terminals, *t t*, covered with thick tubes of hard rubber, *t t*. The rubber disc, *h*, with its metallic segments, S S, was

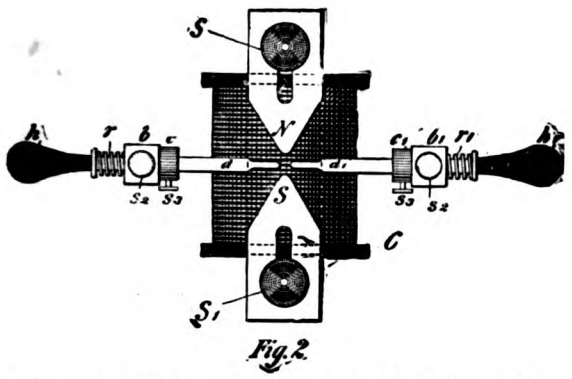

Fig. 2.

Form of Discharger with Magnet Used in the Direct-Current Conversion.

finished in a lathe, and its entire surface highly polished so as to offer the smallest possible frictional resistance to the motion through a fluid. In the hollow of the pulley an insulating liquid, such as a thin oil, was poured, so as to reach very nearly to the opening left in the flange *f*, which was screwed tightly on the front side of the pulley. The terminals, *t t*, were connected to the opposite coatings of a battery of condensers, so that the discharge occurred through the liquid. When the pulley was rotated the liquid was forced against the rim of the pulley, and considerable fluid pressure resulted. In this simple way the discharge gap was filled with a medium which behaved practically like a solid, which possessed the quality of closing instantly upon the occurrence of the break, and which, moreover, was circulating through the gap at a rapid rate. Very powerful effects were produced by dischargers of this kind with liquid interrupters, of which a number of different forms were made. It was found that, as expected, a longer spark for a given length of wire was obtainable in this way than by using air as an interrupting device.

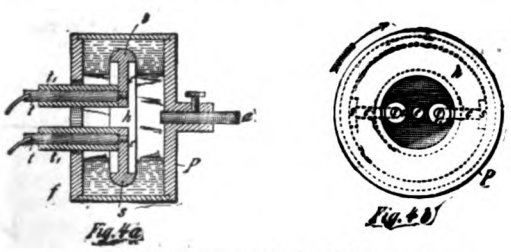

Fig. 4a. Fig. 4b.

Form of Discharger with Liquid Interrupter.

In the diagrammatical sketch (Fig. 1) which has been already, referred to, the cases which are most likely to be met with in practice are illustrated. One has at his disposal either direct or alternating currents from a supply station. It is convenient for an experimenter in an isolated laboratory to employ a machine G such as illustrated, capable of giving both kinds of currents. In such case it is also preferable to use a machine with multiple circuits, as in many experiments it is useful and convenient to have at one's disposal currents of different phases. In the sketch, D represents the direct and A the alternating circuit. In each of these, three branch circuits are shown, all of which are provided with double lines switches, *s s s s s s*. Consider first the direct current conversion; I *a* represents the simplest case. If the E.M.F. of the generator is sufficient to break through a small air-space, at least, when the latter is warmed or otherwise rendered poorly insulating, there is no difficulty in maintaining a vibration with fair economy by judicious adjustment of the capacity, self-induction and resistance of the circuit L containing the devices *l l m*. The magnet N, S, can be in this case advantageously combined with the air-space. The discharger *d d* with the magnet may be placed either way, as indicated by the full or by the dotted lines. The circuit I *a* with the connections and devices is supposed to possess dimensions such as are suitable for the maintenance of a vibration. But usually the E.M.F. on the circuit or branch (Fig. 1), I *a* will be something like 100 volts or so, and in this case it is not sufficient to break through the gap. Many different means may be used to remedy this by raising the E.M.F. across the gap. The simplest is probably to insert a large self-induction coil in series with the circuit L. When the arc is established, as by the discharger (illustrated in Fig. 2), the magnet blows the arc out the instant it is formed. Now the extra current of the break, being of high E.M.F., breaks through the gap, and a path of low resistance for the dynamo current being again provided, there is a sudden rush of the current from the dynamo upon the weakening or subsidence of the extra current. This process is repeated in rapid succession, and in this manner I have maintained oscillation with as low as 50 volts, or even less, across the gap. But conversion on this plan is not to be recommended, on account of the too heavy currents through the gap and consequent heating of the electrodes; besides, the frequencies obtained in this way are low, owing to the high self-induction necessarily associated with the circuit. It is very desirable to have the E.M.F. as high as possible, firstly, in order to increase the economy of the conversion, and, secondly, to obtain high frequencies. The difference of potential in this electric oscillation is, of course, the equivalent of the stretching force in the mechanical vibration of the spring. To obtain very rapid vibration in a circuit of some inertia a great stretching force or difference of potential is necessary. Incidentally, when the E.M.F. is very great, the condenser, which is usually employed in connection with the circuit, need have but a small capacity, and many other advantages are gained. With a view of raising the E.M.F. to a many times greater value than obtainable from ordinary distribution circuits, a rotating transformer *g* is used, as indicated in Fig. II*a*., or else a separate high-potential machine is driven by means of a motor operated from the generator G. The latter plan is in fact preferable, as changes are easier made. The connections from the high-tension winding are quite similar to those in branch 1*a* with the exception that a condenser C, which should be adjustable, is connected to the high-tension circuit. Usually, also, an adjustable self-induction coil in series with the circuit has been employed in these experiments. When the tension of the currents is very high the magnet ordinarily used in connection with the discharger is of comparatively small value, as it is quite easy to adjust the dimensions of the circuit so that oscillation is maintained. The employment of a steady E.M.F. in the high-frequency conversion affords some advantages over the employment of alternating E.M.F., as the adjustments are much simpler and the action can be easier controlled. But, unfortunately, one is limited by the obtainable potential difference. The windings also break down easily in consequence of the sparks which form between the sections of the armature or commutator when a vigorous oscillation takes place. Besides, these transformers are expensive to build. It has been found by experience that it is best to follow the plan illustrated in Fig. 1, III*a*. In this arrangement a rotating transformer *g* is employed to convert the low-tension direct currents into low-frequency alternating currents, preferably also of small tension. The tension of the currents is then raised in a stationary transformer T. The secondary S of this transformer is connected to an adjustable condenser C which discharges through the gap or discharger *d d*, placed in either of the ways indicated, through the primary P of a disruptive discharge coil, the high-frequency currents being obtained from the secondary S of this coil, as described on previous occasions. This will undoubtedly be found the cheapest and most convenient way of converting direct currents.

The three branches of the circuit A represent the usual cases met in practice when alternating currents are converted. In Fig. 1, I *b* a condenser C, generally of large capacity, is connected to the circuit L containing the devices *l l*, *m m*. The devices *m m* are supposed to be of high self-induction so as to bring the frequency of the circuit more or less to that of the dynamo. In this instance the discharger *d d* should best have a number of makes and breaks per second equal to twice the frequency of the dynamo. If not so, then it should have at least a number equal to a multiple or even fraction of the dynamo frequency. It should be observed, referring to (Fig. 1), I *b*, that the conversion to a high potential is also effected when the discharger *d d*, which is shown in the sketch, is omitted. But the effects which are produced by currents which rise instantly to high values, as in a disruptive discharge, are entirely different from those produced by dynamo currents which rise and fall harmonically. So, for instance, there might be in a given case a number of makes and breaks at *d d* equal to just twice the frequency of the dynamo, or, in other words, there may be the same number of fundamental oscillations as would be produced without the discharge gap, and there might even not be any quicker superimposed vibration; yet the differences of potential at the various points of the circuit, the impedence and other phenomena,

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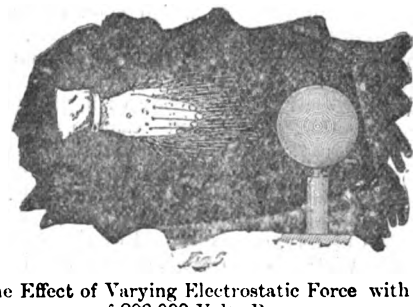
dependent upon the rate of change, will bear no similarity in the two cases. Thus, when working with currents discharging disruptively, the element chiefly to be considered is not the frequency, as a student might be apt to believe, but the rate of change per unit of time. With low frequencies in a certain measure the same effects may be obtained as with high frequencies, provided the rate of change is sufficiently great. So, if a low-frequency current is raised to a potential of, say, 75,000 volts and the high-tension current passed through a series of high-resistance lamp filaments, the importance of the rarefied gas surrounding the filament is clearly noted, as will be seen later; or, if a low-frequency current of several thousand amperes is passed through a metal bar, striking phenomena of impedence are observed, just as with currents of high frequencies. But it is, of course, evident that with low-frequency currents it is impossible to obtain such rates of change per unit of time as with high frequencies, hence the effects produced by the latter are much more prominent. It was deemed advisable to make the preceding remarks, inasmuch as many more recently described effects have been unwittingly identified with high frequencies. Frequency alone in reality does not mean anything, except when an undisturbed harmonic oscillation is considered.

In the branch Fig. 1 III.*b* a similar disposition to that in 1*b* is illustrated, with the difference that the currents discharging through the gap *d d* are used to induce currents in the secondary S of a transformer, T. In such case the secondary should be provided with an adjustable condenser for the purpose of tuning it to the primary.

Fig. 1 II.*b* illustrates a plan of alternate-current high-frequency conversion which is most frequently used, and which is found to be most convenient. This plan has been dwelt upon in detail on previous occasions, and need not be described here.

I will now proceed with the experiments.

On one of the terminals of the coil I have placed a large sphere of sheet brass, which is connected to a larger insulated brass plate, in order to enable me to perform the experiments under conditions, which, as you will see, are more suitable for this experiment. I now set the coil to work, and approach the free terminal with a metallic object held in my hand, this simply to avoid burns. As

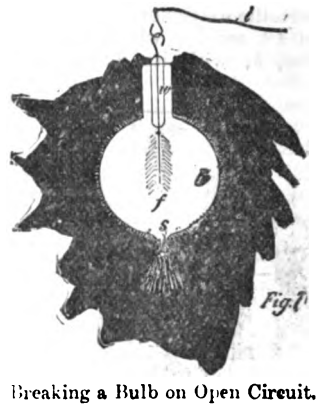


Illustrating the Effect of Varying Electrostatic Force with a Transformer of 200,000 Volts Pressure.

I approach the metallic object to a distance of 8in. or 10in., a torrent of furious sparks breaks forth from the end of the secondary wire, which passes through the rubber column. My arm is now traversed by a powerful electric current, vibrating at about the rate of one million times a second. I can make these streams of light visible to all, by touching with the metallic object one of the terminals as before, and approaching my free hand to the brass sphere, which is connected to the second terminal of the coil. As the hand is approached, the air between it and the sphere, or in the immediate neighbourhood, is more violently agitated, and you see streams of light now break forth from my finger tips and from the whole hand (Fig. 5). Were I to approach the hand closer, powerful sparks would jump from the brass sphere to my hand, which might be injurious. The streamers offer no particular inconvenience, except that in the ends of the finger tips a burning sensation is felt. They should not be confounded with those produced by an influence machine, because in many respects they behave differently. I have attached the brass sphere and plate to one of the terminals, in order to prevent the formation of visible streamers on that terminal, also in order to prevent sparks from jumping at a considerable distance. Attachment is favourable for the working of the coil.

The streams of light which you have observed issuing from my hand are due to a potential of about 200,000 volts, alternating in rather irregular intervals, something like a million times a second. A vibration of the same amplitude, but four times as fast, to maintain which over 3,000,000 volts would be required, would be more than sufficient to envelop my body in a complete sheet of flame. But this flame would not burn me up; quite contrarily, the probability is that I would not be injured in the least. Yet a hundredth part of that energy, otherwise directed, would be amply sufficient to kill a person.

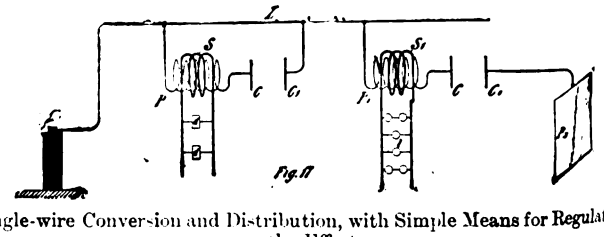
The amount of energy which may thus be passed into the body of a person depends on the frequency and potential of the currents, and by making both of these very great, a vast amount of energy may be passed into the body without causing any discomfort, except perhaps, in the arm, which is traversed by a true conduction current. The reason why no pain in the body is felt, and no injurious effect noted, is that everywhere, if a current be imagined to flow through the body, the direction of its flow would be at right angles to the surface; hence the body of the experimenter offers an enormous section to the current, and the density is very small, with the exception of the arm, perhaps, where the density may be considerable. But if only a small fraction of that energy would be applied in such a way that a current would traverse the body in the same manner as a low-frequency current, a shock would be received which might be fatal.



Breaking a Bulb on Open Circuit.

I now return to the experiment to which I have already alluded, and with which I desire to illustrate a striking effect produced by a rapidly varying electrostatic force. I attach to the end of the wire *l* (Fig. 7), which is in connection with one of the terminals of the secondary of the induction coil, an exhausted bulb *b*. The bulb contains a thin carbon filament, *f*, which is fastened to a platinum wire, *w*, sealed in the glass, and leading outside of the bulb, where it connects to the wire *l*. The bulb may be exhausted to any degree attainable with ordinary apparatus. Just a moment before you have witnessed the breaking down of the air between the charged brass plates. You know that a plate of glass, or any other insulating material, would break down in like manner. Had I, therefore, a metallic coating attached to the outside of the bulb, or placed near the same, and were this coating connected to the other terminal of the coil, you would be prepared to see the glass give way if the strain were sufficiently increased. Even were the coating not connected to the other terminal, but to an insulated plate, still, if you have followed recent developments, you would naturally expect a rupture of the glass.

But it will certainly surprise you to note that under the action of the varying electrostatic force, the glass gives way when all other bodies are removed from the bulb. In fact, all the surrounding bodies we perceive might be removed to an infinite distance without affecting the result in the slightest. When the coil is set to work, the glass is invariably broken through at the seal, or other



Single-wire Conversion and Distribution, with Simple Means for Regulating the Effects.

narrow channel, and the vacuum is quickly impaired. Such a damaging break would not occur with a steady force, even if the same were many times greater. The break is due to the agitation of the molecules of the gas within the bulb and outside of the same. This agitation, which is generally most violent in the narrow-pointed channel near the seal, causes a heating and rupture of the glass. This rupture would, however, not occur, not even with a varying force, if the medium filling the inside of the bulb and that surrounding it were perfectly homogeneous. The break occurs much quicker if the top of the bulb is drawn out into a fine fibre. In bulbs used with these coils such narrow-pointed channels must therefore be avoided.

When the frequencies are very high it has been found in laboratory practice quite easy to regulate the effects in the manner shown in diagram Fig. 17. Here two primaries P and P are shown, each connected with one of its ends to the line L, and with the other end to the condenser plates C and C^1, respectively. Near these are placed other condenser plates C_1 and C^1_1, the former being

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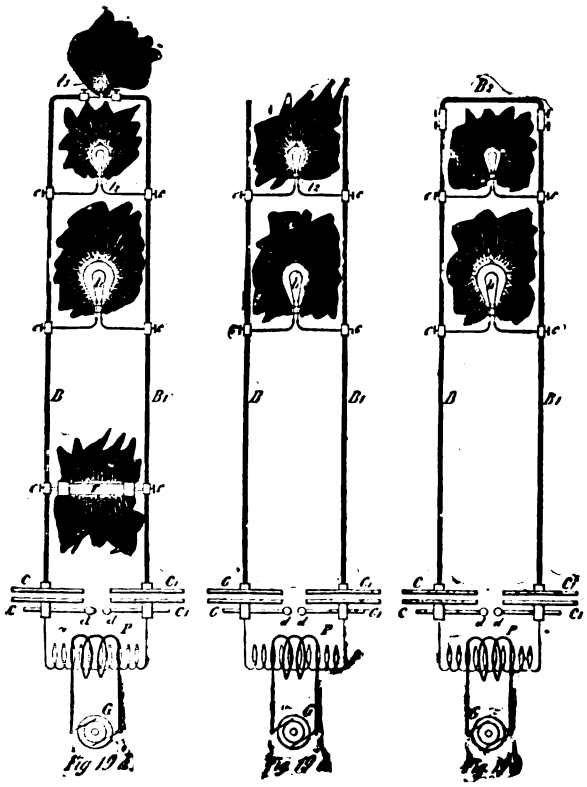
connected to the line L and the latter to an insulated larger plate, P_2. On the primaries are wound secondaries S and S_1 of coarse wire. By varying the distances of the condenser plates C and C^1, the currents through the secondaries S and S^1 are varied in intensity. The curious feature is the great sensitiveness, the slightest change in the distance of the plates producing considerable variations in the intensity or strength of the currents. The sensitiveness may be rendered extreme by making the frequency such, that the primary itself without any plate attached to its free end satisfies, in conjunction with the closed secondary, the condition of resonance. In such condition an extremely small change in the capacity of the free terminal produces great variations. For instance, I have been able to adjust the conditions so that the mere approach of a person to the coil produces a considerable change in the brightness of the lamps attached to the secondary. Such observations and experiments possess, of course, at present chiefly scientific interest, but they may soon become of practical importance.

Among the various current phenomena observed perhaps the most interesting are those of impedence presented by conductors to currents varying at a rapid rate. In my first Paper before the American Institute of Electrical Engineers, I have described a few striking observations of this kind. Thus I showed that when such currents or sudden discharges are passed through a thick metal bar there may be points at the bar only a few inches apart, which have a sufficient potential difference between them to maintain at bright incandescence an ordinary filament lamp. I have also described the curious behaviour of rarefied gas surrounding a

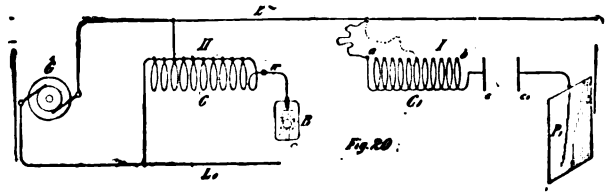


Impedance Phenomena.

conductor to such sudden rushes of current. These phenomena have been since more carefully studied and one or two novel experiments of this kind are deemed of sufficient interest to be described here.

With reference to Fig. 19*a*, B and B_1 are very stout copper bars connected at their lower ends to plates C and C_1 respectively of a condenser, the opposite plates of the latter being connected to the terminals of the secondary S of a high-tension transformer, the primary P of which is supplied with alternating currents from an ordinary low-frequency dynamo G or distribution circuit. The condenser discharges through an adjustable gap *d d* as usual. By establishing a rapid vibration, it was found quite easy to perform the following curious experiment :—The bars B and B_1 were joined at the top by a low-voltage lamp l_3 ; a little lower, was placed, by means of clamps *c c*, a 50-volt lamp l_2, and still lower another 100-volt lamp l_1 ; and finally, at a certain distance below the latter lamp, an exhausted tube T. By carefully determining the positions of these devices, it was found practicable to maintain them all at their proper illuminating power. Yet they were all connected in multiple arc to the two stout copper bars, and required widely different pressures. This experiment requires, of course, some time for adjustment, but is quite easily performed.

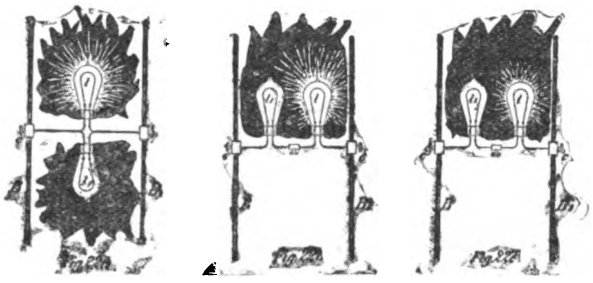
In Figs. 19*b* and 19*c*, two other experiments are illustrated, which, unlike the previous experiment, do not require very careful adjustments. In Fig. 22*b*, two lamps, l_1 and l_2, the former a 100-volt and the latter a 50-volt, are placed in certain positions as indicated, the 100-volt lamp being below the 50-volt lamp. When the arc is playing at *d d*, and the sudden discharges passed through the bars B B, the 50-volt lamp will, as a rule, burn brightly, or at least this result is easily secured, while the 100-volt lamp will burn very low or remain quite dark (Fig. 19*b*). Now the bars B B may be joined at the top by a thick cross-bar B_2, and it is quite easy to maintain the 100-volt lamp at full candle-power while the 50 volt lamp remains dark (Fig. 19*c*). These results, as I have pointed out previously, should not be considered to be due exactly to frequency, but rather to the time rate of change, which may be great even with low frequencies.



Plan Followed in Observing the Effects of Resonance.

In Fig. 20, I., is shown a plan which has been followed in the study of the resonance effects by means of a high-frequency alternator. C is a coil of many turns, which is divided in small separate sections for the purposes of adjustment. The final adjustment was made sometimes with a few thin iron wires (though this is not always advisable) or with a closed secondary. The coil C is connected with one of its ends to the line L from the alternator G and with the other end to one of the plates *c* of a condenser *c* c_1, the plate (c_1) of the latter being connected to a much larger plate P_1. In this manner both capacity and self-induction were adjusted to suit the dynamo frequency.

As regards the rise of potential through resonant action, of course, theoretically, it may amount to anything since it depends on self-induction and resistance and since these may have any value. But in practice one is limited in the selection of these values, and besides these there are other limiting causes. One may start with, say, 1,000 volts, and raise the E.M.F. to 50 times that value, but one cannot start with 100,000 and raise it to ten times that value because of the losses in the media, which are great, especially if the frequency is high. It should be possible to start with, for instance, two volts from a high or low frequency circuit of a dynamo and raise the E.M.F. to many hundred times that value. Thus coils of the proper dimensions might be connected each with only one of its ends to the mains from a machine of low E.M.F., and though



Showing the Effect of the Presence of a Gaseous Medium.

the circuit of the machine would not be closed in the ordinary acceptance of the term, yet the machine might be burned out if a proper resonance effect would be obtained. I have not been able to produce, nor have I observed with currents from the dynamo machine, such great rises of potential. It is possible, if not probable, that with currents obtained from apparatus containing iron the disturbing influence of the latter is the cause that these theoretical possibilities cannot be realised. But if such is the case I attribute it solely to the hysteresis and Foucault current losses in the core. Generally it was necessary to transform upward, when the E.M.F. was very low, and usually an ordinary form of induction coil was employed, but sometimes the arrangement illustrated in Fig. 20, II., has been found to be convenient. In this case a coil C is made in a great many sections, a few of these being used as the primary. In this manner both primary and secondary are adjustable. One end of the coil is connected to the line L_1 from the alternator, and the other line L is connected to the intermediate point of the coil. Such a coil with adjustable primary and secondary will be found also convenient in experiments with the disruptive discharge. When true resonance is obtained the top of the wave must of course be on the free end of the coil as, for instance, at the terminal of the phosphorescence bulb B. This is easily recognised by observing the potential of a point on the wire *w* nearer to the coil.

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In connection with resonance effects and the problem of transmission of energy over a single conductor, which was previously considered, I would say a few words on a subject which constantly fills my thoughts and which concerns the welfare of all. I mean the transmission of intelligible signals, or perhaps even power, to any distance without the use of wires. We now know that electric vibration may be transmitted through a single conductor. Why, then, not try to avail ourselves of the earth for this purpose?

A point of great importance would be first to know what is the capacity of the earth; and what charge does it contain if electrified. Though we have no positive evidence of a charged body existing in space without other oppositely electrified bodies being near, there is a fair probability that the earth is such a body, for by whatever process it was separated from other bodies—and this is the accepted view of its origin—it must have retained a charge, as occurs in all processes of mechanical separation. If it be a charged body insulated in space its capacity should be extremely small, less than one-thousandth of a farad. But the upper strata of the air are conducting, and so, perhaps, is the medium in free space beyond the atmosphere, and these may contain an opposite charge. Then the capacity might be incomparably greater. In any case it is of the greatest importance to get an idea of what quantity of electricity the earth contains. It is difficult to say whether we shall ever acquire this necessary knowledge, but there is hope that we may, and that is, by means of electrical resonance. If ever we can ascertain at what period the earth's charge, when disturbed, oscillates with respect to an oppositely electrified system or known circuit, we shall know a fact possibly of the greatest importance to the welfare of the human race. I propose to seek for the period by means of an electrical oscillator, or a source of alternating electric currents. One of the terminals of the source would be connected to earth as, for instance, to the city water mains, the other to an insulated body of large surface. It is possible that the outer conducting air strata, or free space, contains an opposite charge, and that, together with the earth, they form a condenser of very large capacity. It is certainly practicable to impress an electric vibration, at least of a certain low period, upon the earth, by means of proper machinery. At what distance such a vibration might be made perceptible can only be conjectured. I think that beyond doubt it is possible to operate electrical devices in a city through the ground or pipe system by resonance from an electrical oscillator located at a central point. But the practical solution of this problem would be of incomparably smaller benefit to man than the realisation of the scheme of transmitting intelligence or, perhaps, power to any distance through the earth or environing medium.

On the Light Phenomena produced by High-frequency Currents of High Potential and General Remarks relating to the Subject.

Returning now to the light effects which it has been the chief object to investigate, it is thought proper to divide these effects into four classes:—(1) Incandescence of a solid; (2) Phosphorescence; (3) Incandescence or phosphorescence of a rarefied gas; and (4) Luminosity produced in a gas at ordinary pressure. The first question is, How are these luminous effects produced?

In Figs. 22*a*, 22*b*, and 22*c* the heavy copper bars B B_1 are connected to the opposite coatings of a battery of condensers, or generally in such way that the high frequency or sudden discharges are made to traverse them. I connect first an ordinary 50-volt incandescent lamp to the bars by means of the clamps *c c*. The discharges being passed through the lamp, the filament is rendered incandescent, though the current through it is very small, and would not be nearly sufficient to produce a visible effect under the conditions of ordinary use of the lamp. Instead of this I now attach to the bars another lamp exactly like the first, but with the seal broken off, the bulb being therefore filled with air at ordinary pressure. When the discharges are directed through the filament, as before, it does not become incandescent. But the result might still be attributed to one of the many possible reactions. I therefore connect both the lamps in multiple arc as illustrated in Fig. 22*a*. Passing the discharges through both the lamps, again the filament in the exhausted lamp *l* glows very brightly, while that in the non-exhausted lamp l_1 remains dark, as previously. But it should not be thought that the latter lamp is taking only a small fraction of the energy supplied to both the lamps; on the contrary, it may consume a considerable portion of the energy and it may become even hotter than the one which burns brightly. In this experiment the potential difference at the terminals of the lamps varies in sign theoretically three to four million times a second. The ends of the filaments are correspondingly electrified, and the gas in the bulbs is violently agitated and a large portion of the supplied energy is thus converted into heat. In the non-exhausted bulb there being a few million times more gas molecules than in the exhausted one, the bombardment, which is most violent at the ends of the filament, in the neck of the bulb, consumes a large portion of the energy without producing any visible effect. The reason is that, there being many molecules, the bombardment is quantitatively considerable, but the individual impacts are not very violent, as the speeds of the molecules are comparatively small owing to the small free path. In the exhausted bulb, on the contrary, the speeds are very great and the individual impacts are violent, and therefore better adapted to produce a visible effect. Besides, the convection of heat is greater in the former bulb. In both the bulbs the current traversing the filaments is very small, incomparably smaller than that which they require on an ordinary low-frequency circuit. The potential difference, however, at the ends of the filaments is very great and might be possibly 20,000 volts or more, if the filaments were straight and their ends far apart. In the ordinary lamp a spark generally occurs between the ends of the filament or between the platinum wires outside before such a difference of potential can be reached.

It might be objected in the experiment before shown that the lamps being in multiple arc, the exhausted lamp might take a much larger current, and that the effect observed might not be exactly attributable to the action of the gas in the bulbs. Such objections will lose much weight if I connect the lamps in series, with the same result. When this is done, and the discharges are directed through the filaments, it is again noted that the filament in the non-exhausted bulb, l_1, remains dark, while that in the exhausted one, *l*, glows even more intensely than under its normal conditions of working (Fig. 22*b*). According to general ideas the current through the filaments should now be the same, were it not modified by the presence of the gas around the filaments.

At this juncture I may point out another interesting feature, which illustrates the effect of the rate of change of potential of the currents. I will leave the two lamps connected in series to the bars B B_1, as in the previous experiment (Fig. 22*b*), but will presently reduce considerably the frequency of the currents, which was excessive in the experiment just before shown. This I may do by inserting a self-induction coil in the path of the discharges, or by augmenting the capacity of the condensers. When I now pass these low-frequency discharges through the lamps, the exhausted lamp, *l*, again is as bright as before, but it is noted also that the non-exhausted lamps, l_1, glows, though not quite as intensely as the other. Reducing the current through the lamps, I may bring the filament in the latter lamp to redness, and, though the filament in the exhausted lamp, *l*, is bright (Fig. 22*c*), the degree of its incandescence is much smaller than in Fig 22*b*, when the currents were of a much higher frequency.

(To be continued.)

APPLICATION OF ELECTRICITY TO THE DEVELOPMENT OF "DIP" WORKINGS, AND TO OTHER PURPOSES, AT LOGANLEA COLLIERY.

At the last meeting of the Scottish Branch of the Association of Colliery Managers, held in Edinburgh, Mr. Robert Weir, manager, read a very valuable Paper on this subject. The available area of the most valuable seam of coal in the pit, he said, being nearly exhausted to the rise, the proprietor desired to get to the dip where the coal lay virgin. In order to develop the latter an extensive and efficient hauling and pumping plant was necessary; and to proceed on the general lines of the methods most approved of until recently presented difficulties.

Already the electrical transmission of energy had engaged the attention of the mining community, and successful and economic installations were in operation at various collieries; and although the natural conditions of Loganlea colliers, to a great extent, secured immunity for dangers arising from the sparking of the different parts of the machinery, or the breaking of the conductors, still the reluctance to adopt a power whose properties and laws entailed on the colliery engineer special study and experiment, was not overcome until careful observation and inquiry revealed the fact that not only was electricity entirely suited for the development of dip workings, but was pre-eminently a power adaptable to coal-cutting and the driving of fans and other machinery underground and situated long distances from the shaft. To the further application of electricity to these purposes, then, the desired plant was designed and erected.

The surface erection consists of a diagonal engine, having an 18in. cylinder by 30in. stroke, together with a 40-unit compound dynamo, capable of developing a current of 200 amperes at 200 volts when running at 600 revolutions. The cables in the shaft are conveyed from the engine-room switchboard to one similarly equipped underground. The conductors are insulated and protected by a lead cover. The cables are secured in the shaft in pitch-pine casings, suspended from a steel-wire rope.

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After describing the haulage plane from the dip-end of the pit, the haulage apparatus, drums, gearing, &c., and the composition of the trains, the author went on to say that by means of a rheostat, in conjunction with the break-switch, sufficient resistance could be cut out to increase the periphery speed of the drums from two to four miles per hour, or *vice versâ*. With this haulage it is intended to extend the dip-plane to a distance of 700 yards, and already a length of 180 yards has been won. The drum motor is series-wound, and is capable of working up to 30 H.P. Next in order, the pumping machinery was described in detail, the amount of water to be raised from the pit bottom being about 240 gallons per minute; and the author remarked that a resistance coil is also in use at the pump motor, which is of similar construction to that at the haulage; and the number of strokes may be regulated from 30 to 45. For nearly twelve months this plant has now been in operation and its success fully demonstrated. In some measure this result may be attributed to Mr. William M'Whirter, of the Faraday Electrical Works, Govan, near Glasgow, who designed and erected the whole electrical installation, as before entering upon a contract he thoroughly familiarised himself with the circumstances incidental to mine haulage and pumping and the exigencies likely to demand special contrivances in the construction of dynamo motors.

In contemplating the introduction of new or improved machinery, the first cost is often the only consideration from an economical standpoint, the efficiency and facilities for prospective development being entirely disregarded. At Loganlea it would have been a simple matter to have erected an engine on the surface, and conducted the haulage on the ordinary "dook" method; but already an endless rope from the hill occupied much of the available space set apart for haulage in the shaft, and a complication of ropes was not desirable. Further, the hauling from another seam to the same pit bottom was then a question within practical limits, and about two months ago this was satisfactorily accomplished by the application of electricity to the tail-rope system. In view of these several haulages and the water to be pumped, it was apparent that, even in the matter of first cost, an electrical installation was the most economical, when compared with the expense of the several engines, the pump, and the requisite steam-pipes and fittings. The transmission of power electrically, and the ease with which the current may be subdivided and controlled, offered inducements which have been wholly realised; and to some extent this may be due to the provision of a dynamo, the output of which so far has not been overtaxed.

The first experience of the pump was not so successful as had been desired, for after six weeks' work a perceptible sparking at the commutator increased to intermittent flashes, ultimately burning the insulation of the armature-winding; and on examination of the several parts of the motor no satisfactory reason could be assigned for this. It was then suspected that the vibration of the helical gearing, transmitting, as it did, a lateral motion to the armature, had somewhat loosened the winding, and the continual friction gradually wore away the insulation until a short circuit resulted. To counteract this apparent defect in the helical gearing the pinion on the motor shaft was allowed to slide free, the key being replaced by a feather fitted on the shaft. Thereafter the pump continued to work smoothly for a month, when sparking and flashing were again repeated. It was then resolved to substitute for the helical gearing on the motor and intermediate shafts engine-cut steel wheels of the ordinary description. At this time the experience acquired by the manager suggested the advisability of providing a supplementary armature for the pump, and as the confidence in the one then in use had been shaken, it was resolved to test the new gearing and a second armature on the same occasion. That test was entirely satisfactory, and extended to a period of nine weeks, during which time the pump was only allowed to stand for five minutes in every twelve hours, the number of revolutions of the armature per minute averaging 500.

Next followed some remarks on the desirability of using an electrical governor on the engine of the most approved character, on the calculation of the horse-power expended in mine haulage and pumping, on the computation of the horse-power requisite for the working of the tail-rope haulage, and on the advantages resulting in the development of dip-workings by the use of electricity; and then Mr. Weir proceeded to make some conclusions in the following terms: In none of the industries to which electricity has been successfully introduced within recent years, he said, is the same opportunity presented for general application as in mining, nor do the laws of nature in any other sphere operate with such adverse tendency. The security of life, the safety of the mine, and the efficiency and economy of the different appliances are matters which must alike engage the attention of mine managers and electrical engineers. The dissipation of electrical energy in no way interferes with the ventilation of the mine, though at Loganlea (where each of the motors is placed in the intake air-way) shortly after the installation was in operation, complaints as to vitiated air were numerous; they were, however, purely imaginary.

THE ELECTRICAL TRADES SECTION.

A meeting of the Electrical Trades Section of the London Chamber of Commerce was held on the 2nd inst. at the offices of the Chamber, Botolph House, Eastcheap, under the presidency of Major Flood Page.

The SECRETARY (Mr. Kenric B. Murray) having read the minutes of the last meeting, which were approved by the present meeting,

The CHAIRMAN said he would like to make a few remarks before they went to the matters referred to on the agenda. It was a long time since they had held a meeting of the Section, but although that was the case they had not been idle, for they had had no fewer than thirteen meetings of one description or another since the minutes just read were recorded. He desired to draw their attention to a matter which concerned not only the electrical but all trades—namely, the London Chamber of Arbitration, which had been formed by the London Chamber of Commerce, and the City Corporation. They had now got together about 1,100 arbitrators representing most of the trades in London, and although old contracts which existed, and in which another way was provided for settling disputes, hindered the rapid progress of the Chamber of Arbitration, yet they would be interested to learn that up to April last nine cases had been decided by that body. The average amount of fees paid in these cases had been only £5. 12s., and one amount in dispute was no less than £40.000. He had been requested to draw their attention to the fact that a very simple clause had been agreed upon, and it was the hope of the Chamber of Commerce and of the Corporation that the electrical companies and all who were interested in electrical business would try and get the clause into their contracts, just as all the other trades were doing. The clause was as follows:—"All disputes which may arise relating to this contract shall be submitted to arbitration under the rules for the time being of the London Chamber of Arbitration." He thought it might be claimed for this system that it was expeditious, economical, and efficient, and he commended it to their careful consideration. There was another matter which he had been desired to bring before the meeting. In their business they had happily not yet had many disputes between employers and employed, but there was a London Conciliation Board also in connection with the London Chamber of Commerce. The Board consisted of an equal number of employers and employed, who met on an absolute equality. Mr. Boulton was the Chairman of the Board, which had been meeting for three years, and the results had undoubtedly been very satisfactory, none of the decisions which had been arrived at having been disputed yet by either side. As the electrical industry grew they would probably be more interested in the matter.

Mr. SYDNEY MORSE said he thought it ought to be understood that if the clause which had been read by the Chairman were put into any contract it was absolutely irrevocable.

The CHAIRMAN stated that that was so. The London Chamber of Arbitration was a legal court, and with the clause which he had read put into a contract, no other system of arbitration was open under that contract. With reference to the matters which were to come before them that day, as set out in the agenda, he would not anticipate anything that might be done either in regard to overhead wire regulations or as to the question of traction. They had had many meetings of the Overhead-Wire Committee, and he held in his hand certain private correspondence which had taken place between the Board of Trade and the Institution of Electrical Engineers. He might state that the trade was in a much better position, by reason of the action which had been taken by the Section, than they were a little time ago. It would be very much to the advantage of the Section if they could work with the Institution—if the latter would go as far as they wished. With regard to the question to be brought before them by Mr. Gareke, the principle involved in it was that power was to be sought for the appointment of a Sub-Committee which should not come under the ordinary rules governing the sub-committees of their Section, but that it should be a Sub-Committee with power to raise funds and take such action as might be necessary in the interests of a particular portion of the electrical industry. A separate Association existed already with respect to the supply companies outside their organisation. Most of them, who had been connected with the Electrical Trades Section from the commencement, had always felt that it was a great pity that a number of associations outside the Electrical Trades Section of the London Chamber of Commerce should be formed. They had always felt that if it were possible and consistent with the rules of the Chamber, it would be better that committees should be formed in connection with the Chamber. It had been suggested whether it would be advisable that Papers should be read and discussions take place next winter on purely commercial matters, which were really in the interest of the Section, but were outside the special work of the Institution of Electrical Engineers.

Mr. CROMPTON, referring to the subject of overhead-wire regulations, said he thought there was no doubt that matters had advanced a stage, and that the Board of Trade would ask to have assistance. If not, he thought that the Institution would be entitled to call in the assistance of the Electrical Trades Section to put pressure on the Board to receive a deputation again, and to point out that the existing regulations in connection with their industry were far from perfect in many ways.

General WEBBER said that if the correspondence referred to were circulated among the meeting, the members would be satisfied to find, he thought, that the Board of Trade, while demurring to making any important changes unless the necessity for them were fully established, were quite ready to meet the wishes of the Council of the Institution of Electrical Engineers, and at the same time the Board of Trade knew that it would be meeting the wishes of the Chamber of Commerce. The fundamental points discussed by the Committee of the Section and by the Committee of the Institution had been brought before the Board of Trade in the correspondence. He fully believed with Mr. Crompton that the Board of Trade were quite alive to the importance of certain alterations being made for the benefit of the industry.

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On the motion of Mr. GARCKE, seconded by Mr. CROMPTON, it was decided to refer the correspondence to the Overhead-Wires Committee.

The CHAIRMAN stated that the next subject on the agenda was electric traction.

Mr. GARCKE stated that the objects he had in view in proposing the motion, notice of which had been given, were, as the Chairman had said, that the undue multiplication of societies or organisations to deal with electric matters might be prevented, and to enhance the value and the scope of the Electrical Trades Section. The Chairman had already referred so fully to the desirability of those objects that it relieved him of the necessity of saying very much. The only object he had in view in bringing the matter forward was the desirability of merging the organisation which had already been formed into the organisation of the London Chamber of Commerce. They had all probably already heard of the formation of the Electric Traction Association for the purpose of preparing evidence and for other purposes in view of the appointment of a Joint Committee of both Houses of Parliament to deal with traction questions. It had occurred to him that it might be advantageous to the gentlemen who had constituted themselves into that Association to carry out their purposes by means of a sub-committee of the Electrical Trades Section, and he had therefore consulted with Mr. Murray as to whether such a course was practicable and consistent with the organisation of the London Chamber of Commerce. Mr. Murray had informed him—after consulting, he believed, with his Chairman—that it was quite practicable and quite in accord with the rules of the Chamber, and, as the Chairman had explained to them, it only required the passing of a resolution by their Section approving the formation of such a Committee, and the confirmation of the resolution by the Council of the Chamber to complete the arrangement. As the Chairman had pointed out, it was undesirable to have several organisations dealing with the various questions which from time to time cropped up, and if they came into the organisation afforded by the section to deal with such questions, it must be to the advantage of all parties. He believed, altogether, that his proposal would commend itself to the meeting at once. The proposal was as follows:—"That this Section approve of the formation of an electric traction sub-committee, with power to raise funds, engage Counsel, and take such other steps as may be in their opinion necessary for the advocacy or protection of traction interests." It must be in the form of such a committee, in order to enable them to raise funds. That had always been the difficulty that had blocked the way to the formation of such committees—that they had understood that they were not able to raise funds for their own specific purposes; but Mr. Murray had informed him that there was no objection to this, that such a committee would have the right to spend money on objects which were deemed advisable, and that it would not be controlled by the other committees or by the Section. His resolution went on:—"That the following members constitute the sub-committee, with power to add to their number. (Then the names would come in.) Such sub-committee shall be confined to the above members, and to such others as shall be elected by them, provided that no one shall be eligible for election as a member of such sub-committee who is not a member of the London Chamber of Commerce; and the sub-committee shall be subject to the general rules of the Chamber, and shall report from time to time to the Electrical Section."

General WEBBER seconded the resolution.

Mr. GAINE (General Manager of the National Telephone Company) said he would like to ascertain, in the first instance, what the exact object and meaning of such a committee, if appointed, was. He did not think it required very much divination to ascertain what the intention was. They all knew, he thought, that the suggestion was really the formation of a protection committee—to protect one interest as against another interest—which was also represented in the London Chamber of Commerce; that was to say, it really, after all, became a question between the electric traction interest and the telephone interest. He thought it very possible that the railway interest might be affected, but the matter was very much between electric traction and the telephone interest. For a number of Sessions certain clauses had been inserted in certain Acts of Parliament for protecting the telephone interest as against the traction interest, and matters had now come to this point: that a Joint Committee of both Houses of Parliament had been appointed, and would very shortly sit in order to go into the merits of the whole question as between these different interests, and to determine whether the telephone or any other interest was entitled to any protection, and, if so, what protection, and to settle any clauses that might be thought right and proper. As Mr. Garcke had said, there was an Association outside the London Chamber of Commerce for the protection of the traction interest, and what he (the speaker) wanted to know was this: Was the object and intention of the appointment of the proposed committee solely or mainly for the purpose of obtaining the influence and the weight at their back which the name of the London Chamber of Commerce would give them in the inquiry which was to be held. He ventured to say that if that were the object and intention, it was a most improper suggestion, that one interest, represented in the London Chamber of Commerce, should seek to have the weight of the Chamber at its back as against another interest also represented in the Chamber. At any rate, unless it could be clearly shown to be in the public interest, he maintained that there was no ground for such a proposal as that which had been submitted to the meeting. He had looked through the rules and bye-laws which had governed the Chamber, and he could not find anything whatever specific which dealt with the case of conflicting interests; but he did find a provision, as had been pointed out, that no resolution which was passed by a Trades Section was to have any force or effect until it was confirmed by the Council or the Chamber itself. What he wanted to arrive at was, as he had said, whether the sole or main object of the appointment of the proposed committee was for the purpose of obtaining the weight at its back of the name of the London Chamber of Commerce in the conflict which was about to take place before Parliament, and as against another interest which was equally a member of the Chamber; because he reiterated that, in that case, it was, in his opinion, a most improper suggestion to make, and a course of proceeding which he objected to, as a member of the Chamber, in the strongest possible terms, and one which, he ventured to say, the Chamber would be very wrong to take up unless a strong case were shown that it would be right for them to do so in the public interest. There had been no suggestion by the mover of the resolution that any question of public interest was involved in it. If such a suggestion had been made he would have been very glad to have answered it, because he was quite prepared to show that the public interest was quite as much, if not more, on the side of the interest attacked by the resolution as it was on the side of the interest proposing it. As far as he was concerned, on behalf of one very large interest represented in the London Chamber of Commerce, he objected in the strongest possible way to the passing of the resolution.

The CHAIRMAN said he could only state, with respect to Mr. Gaine's question whether it was the intention to have the weight of the Chamber in favour of one Section as against another Section, that it was open to the interest represented by Mr. Gaine to form a similar committee on its own behalf. The proposal was brought forward with the view of really lessening the sharpness and the acuteness of the antagonism. The fight must go on, and the question was should it go on entirely outside without any of the advantages which might accrue from their meeting inside.

Mr. GAINE stated that he did not want to oppose the proposal except on the ground which he had brought forward. A Parliamentary inquiry was about to be held, and he desired to know whether the name of the London Chamber of Commerce would in any way be associated with the traction interest represented before the inquiry.

The SECRETARY said he presumed that the proposed sub committee desired to act only as a Traction Sub-Committee.

Mr. GARCKE: As the Traction Sub-Committee of the London Chamber of Commerce.

Mr. MORSE observed that the fact that Sir Albert Rollit was President of the Chamber and a Director of the National Telephone Company would not give greater weight to his evidence, any more than the fact that they were a sub-committee of a Section of the London Chamber of Commerce would give weight to theirs.

The CHAIRMAN reminded them that when they had met before he had expressed each time the matter had been discussed that their object was to lessen the acuteness of the fight. His view of the matter was that it was not intended, and that it would not be possible for the proposed committee to take any higher position than that they were a sub-committee of the Electrical Trades Section of the London Chamber of Commerce.

Mr. GAINE: Representing a particular interest?

The CHAIRMAN: Representing absolutely a particular interest.

Mr. GARCKE, in answer to a question, said that the proposed resolution had been carefully considered, and he did not think they would be empowered to omit the reference in it to raising funds and engaging counsel. An association had been already formed, and his desire was to prevent the multiplicity of other societies and to consolidate all electrical interests rather than to have them scattered.

Mr. GAINE: The funds of the Chamber are not in any way involved if the resolution is carried?

Mr. GARCKE: No.

The CHAIRMAN stated that he also added the following words at the end of the resolution:—"And in this case the President of the Chamber, the Chairman of the Council, and the Chairman and Vice-Chairman of the Electrical Section shall not be *ex-officio* members of the sub-committee." He then put the resolution, which was carried, Mr. GAINE remarking that he supposed he might be in a minority of one.

Mr. GAINE asked when it would be confirmed.

The SECRETARY: On the 8th.

On the motion of Mr. GARCKE, the following gentlemen were nominated to be the sub-committee, with power to add to their number:—Messrs. Crompton, Morse, Kite, Babcock-Wilcock, Sellon, and Garcke.

The CHAIRMAN stated that the next matter on the agenda was to consider the desirability of representations being made to the Railway Association that a special rate should be granted for the carriage of electrical wire and cable. The question originated in a correspondence that had taken place between Mr. Murray and Messrs. W. T. Glover and Co.

Mr. HENRY EDMUNDS (Messrs. Glover and Co.) stated that they were all suffering with others in regard to the advance of railway rates, and they had no goods that came under the companies' classifications where they could take their own risk as owners, as against the companies' risk. It would be useful if the companies would allow them to have their own risk as owners.

The question was referred to the Railway Rates Committee of the Section.

The CHAIRMAN said he was present at a meeting of the Council a short time ago, when a member of the Council proposed a resolution which he (the Chairman) felt that it was not ripe for them to discuss, and it was therefore referred to the Section.

The SECRETARY read the resolution, which was as follows:—"That in view of the competition of the New Telephone Company having been virtually extinguished by the amalgamation with the National Telephone Company, the commercial interests of the City of London, as concerns the present telephone monopoly, be vigilantly guarded by the Council of the Chamber, and that, further, the Council be requested to draft an amendment to the National Telephone Company's Bill now before Parliament, to insert a clause forbidding any preferential treatment of any subscriber without proper notice to the other subscribers of such preference; such draft amendment to be placed in the hands of the President of the Chamber, with a request that he should move the same at a fitting opportunity."

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The CHAIRMAN said that the Council had never seen the Bill referred to, nor had he seen it.

Mr. GAINE stated that there was such a Bill, but it was in a state of suspended animation.

General WEBBER said that if he were not mistaken the Post Office licence provided for the protection of the public in the particular matter in question.

On the motion of Mr. MORSE the subject was postponed, and the meeting then terminated.

CORRESPONDENCE.

THE ELECTRO-CHEMICAL EQUIVALENT OF ZINC.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In commenting on the account of some experiments on the electro-chemical equivalent of zinc, which you published in your issue of June 2nd, you remark that the slight film observed on parts of the zinc plates may have been due to impurities in the plates themselves. I should think that this was very likely the case, as, though the anodes, from which the zinc is electrolytically dissolved, were of the material known in commerce as "pure zinc," the cathodes were of ordinary sheet zinc.

It seems worth while to draw attention to the use made of limits in these experiments. Two values, namely, 0·0003391 and 0·0003381, were found; each from a group of three experiments. In one of these groups the electrolyte was slightly acidified so as to give it a very slow solvent action on the plates. In the other group the action of the electrolyte caused a slight gain of weight. Hence it seems that the value given by a solution which had no independent effect on zinc, and which, therefore, should be the true value, must lie between these.

With regard to the atomic weight of zinc, I remember having noticed that the value I had deduced by comparison with copper was within about one-half per cent. of a result given by Dr. Gladstone and Mr. Hibbert in the *Proceedings* of the Chemical Society for 1888, if I remember rightly.—Yours, &c., J. ERSKINE MURRAY.

40, Montgomerie-drive, Glasgow, W., June 4, 1893.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your current issue is a Paper by Mr. Murray on the "Electro-Chemical Equivalent of Zinc," which you remark has a bearing on the atomic weight of zinc. It may, therefore, interest you and your readers to know that some years ago Dr. Gladstone and I determined the atomic weight of zinc by a voltametric method. I enclose a copy of our Paper, from which you will see that there are several points of difference between our method and Mr. Murray's.

Our standard was the silver voltameter. This is acknowledged to be more accurate than copper sulphate as commonly used, though Mr. Gray has shown how to get the very best results with it.

Our mean ratio for the equivalents of silver and zinc was 3·298 to 1, which gives 0·0003389 as the electro-chemical equivalent of zinc per ampere per second.

This is very close to the mean of 0·0003386 given by Mr. Murray. But I think that gentleman will acknowledge that the true value is probably nearer that obtained with neutral solutions of the zinc sulphates. Indeed, this is shown by the figures given in Mr. Murray's Paper for the loss sustained by zinc when standing in the neutral and acid liquids.

I therefore suggest that Mr. Murray ought to allow greater weight to the higher of the two values he obtained. Let that result be given a weight twice as great as the other, and the true mean becomes 0·00033877.

This is still nearer our value, the difference being only 1 in 2,500.

Another point of interest may be noted. Our method was to compare the amount of zinc dissolved at the anode with the amount of silver deposited. As the result obtained by Mr. Murray for deposited zinc agrees so well with ours for the zinc dissolved *at the other side of the voltameter*, the two results form an admirable illustration of the equivalence of the chemical action at the two electrodes.

I reserve some remarks on the atomic weight for another place.—Yours, &c., W. HIBBERT.

14, Goldhurst-terrace East, N.W., June 6, 1893.

THE TESTS OF A LARGE "CASTLE" DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On page 114 of your last issue you make some interesting remarks on temperature tests of dynamos occasioned by a rather great difference between the rise of temperature given for Messrs. J. H. Holmes's dynamo (illustrated in the previous number of *The Electrician*), as obtained from two independent tests, Prof. Kennedy's figure being 72, and that printed under my name 44·7° F. Will you kindly allow me to state that I cannot take the responsibility for the latter figure. The armature temperature at the end of the run was 57° C., that of the engine-room 26·5° C, the difference, 30·5° C., *i.e.*, 54·9° F. is the figure, which I would call the rise of temperature *of the armature bars*; but the greatest temperature rise, which I found in the armature is 72·9° F. The 44·7, you will see, refers to the rise of temperature of the armature itself, irrespective to a certain extent of the surrounding atmosphere, and is, as far as I can see, of no interest whatever. It was not suggested by me.

The temperature rise of 72·9° F. was measured in the winding across the ends of the drum, that of 54·9 on the outside of the cylinder formed of the bars. The latter is representative of the type of the dynamo depending on the kind of armature-bars and the kind of core used in the machine. The higher figure, the 72·9°, being the rise in the end-winding, where there are no eddy currents to cause a rise of temperature, depends mainly on the amount of draught admitted to the spirals of strips of which this winding consists. In the present machine, with its heavy insulation, the draught was small. I have no doubt that a little attention to this point, on the part of the makers, will enable them to get the maximum rise in this type of machine down to that given above for the armature bars, *i.e.*, to about 55° F.

You also compare the steam consumption in the engine, which is, according to Prof. Kennedy, 20·3lb., by my own test 21·66lb. per electrical horse-power hour. I would like to say that the difference is accounted for, I believe, by an earlier cut-off being used in Prof. Kennedy's test than in my own, which was a preliminary one.—Yours, &c., F. V. ANDERSEN.

PHYSICS AND METAPHYSICS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your most interesting leader on the above subject, you have challenged metaphysicians to say whether physics can gain anything by going behind the scenes into metaphysics. Far be it from me to seem to accept the challenge, for I have never been lured very far into the tangled waste and weedy ground of metaphysics; but it occurs to me that your readers may like to have a note or two, culled from authors of acknowledged fame. Firstly, the genius of Kant—that star of the first magnitude—attracts us; and we find him telling us "*that those who engage in metaphysical pursuits are far from being able to agree among themselves, but that, on the contrary, this science appears to furnish an arena specially adapted for the display of skill or the exercise of strength in mock contests—a field in which no combatant ever yet succeeded in gaining an inch of ground—in which, at least, no victory was ever yet crowned with permanent possession.*"* The history of metaphysics, both before and since the time of Kant, establishes this grave indictment. Clerk Maxwell says: "*I would advise those who study any system of metaphysics to examine carefully that part of it which deals with physical ideas.*"† It is clear that Maxwell was in the habit of testing his metaphysics by his physics, instead of *vice versâ*.

When we hear that there is a Guy-Fawkes-like attempt to blow up the foundations of a deductive science like dynamics, it is time to see whether it is really a gunpowder plot, or if,

* "Critique of Pure Reason."—I. Kant.

† "Matter and Motion."—Clerk Maxwell.

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perchance, there may not be only dust in the bags instead of powder. If, as is reported, Prof. Lodge asserts that the notion of action at a distance is, *à priori*, as tenable as that of action through a medium, he does so, not in virtue of, but in direct defiance of the recognised systems of metaphysics. However they may disagree, those systems are agreed that the *à priori* is that which is absolutely necessary to thought, as contrasted to the *à posteriori*, or that which is imposed on thought—empirically—by acquired experience. Now, to assert that the human mind might be able to subject itself logically to an objective world in which action at a distance might be possible, would be equivalent to saying that the human mind is capable of cognising a causeless phenomenon, or an event without any contiguous impulse to produce it; which is manifestly incorrect. The notions of contiguous action, of the conditions implied by Newton's first and second laws, and the idea of force expressed by the second law, are not *mere* matters of experience; they are apodeictic necessities, and proceed from the inability of the mind to evolve any idea of a self-producing phenomenon in space and time. The very ether is only to be believed in because the human mind is incapable of conceiving of stress, propagation, retardation, &c.—in a word, *force*—apart from a material medium. Deny Newton's laws, and one may have a moving body retarded without anything to retard it; one may have light refracted without any ether to refract it; one may have any amount of interesting *phenomenon* in the universe without any cause whatever! But one cannot deny Newton's laws; it is logically impossible—only a sophist like Zeno could deny them. Not because the laws are established by experience (for they are *not*), but because the truth of them proceeds from the very pith and marrow of one's inner consciousness. Rather than deny these laws every physicist would invent any number of complicated ethers!

Referring briefly to another point, it seems to me that your definition of an axiom as "concept based on experience" must include all *à posteriori* concepts under the class of axioms, making all inductive knowledge axiomatic. It is experience that tells one that potassium and sulphuric acid evolve hydrogen; and a number of such experiences may evolve the concept that potassium and an acid will evolve hydrogen. But this concept would, I think, scarcely bear elevation to the dignity of a chemical axiom. The definition of an axiom is one of the most difficult to make—perhaps it is axiomatic! Lotze defines an axiom as an "immediate truth;" and Kant as "a synthetical judgment *à priori*;" but neither of these gets over the difficulty that what is an axiom in A.D. 1600 is "bosh" in A.D. 1893.—Yours, &c.,

E. TREMLETT CARTER.

June 2, 1893.

USEFUL FORMULÆ, &c.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: For those who wish to have an idea of the watts per pound a machine gives, knowing the output in kilowatts or units, and weight in cwts., the following rule will, I think, prove acceptable.

Rule.—Nine times the number of units per cwt. will give the number of watts per pound. So that 1 unit per cwt. signifies 9 watts per pound. This is correct within less than 1·25 per cent.—Yours, &c.,

ARTHUR F. GUY.

June 1, 1893.

"THE ENGINEERING MAGAZINE."—The June issue of the *Engineering Magazine* (which can be obtained at the offices of *The Electrician*) contains articles of interest to the electrical and engineering professions, amongst which are the following:—"Great Britain at the World's Fair," by Mr. James Dredge; "The Latest and Greatest Cunarder"; "Evolution of the Ironfounder's Art," by Mr. S. Bolland; "The Trans-Siberian Railway," by Mr. F. Hobart; "The American Passenger Elevator," by Mr. T. E. Brown; "Fire Risks in Electric Insulation," by Prof. Perrine. The articles by Mr. W. M. Acworth on "English and American Railways," and by Prof. Thurston on "Progress in Steam-Engineering," are continued; and many articles of general public interest are included.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week*]

TENDERS INVITED.—The Corporation of Bury (Lancs.), invite tenders for electric lighting plant, which are to be in by July 15th.

——— Tenders are required for the lighting and maintenance of the public street lamps of Plympton St. Mary and Plympton Maurice (Devon), from September, 1893, to April, 1894, and must be in by the 17th inst.

——— Our readers are reminded that the tenders for electric cables, conduits, feeding boxes, &c., for the Urban Sanitary Authority of Portsmouth, have to be in by 10 a.m. on the 23rd inst.

——— The Council of the city of Worcester invite tenders for the erection of their electric lighting station and buildings at Powick Mills, near Worcester. Tenders have to be in not later than the 24th inst.

TENDERS ACCEPTED.—The Ealing Local Board have adopted the recommendation of the experts appointed by the Board in connection with the electric lighting scheme, and have accepted the tender of Messrs. Watts and Co. for the construction of boilers and machinery at the Southern Sewage Works.

——— The tender of Messrs. Allen and Co. has been accepted for the erection of the electric lighting station for the Kingston-on-Thames Town Council, for the sum of £3,656.

——— As stated in our issue of May 19th, the tenders of Messrs. Horsfield (Dewsbury), Messrs. Crompton and Co., Limited (London), and Messrs. Siemens Bros. and Co., Limited (London), have been accepted for electric light and plant for this borough. The amounts are as follows:—

Messrs. Crompton and Co. (Limited), for engines, dynamos, switch-boards, accumulators, &c.	£6,257
Messrs. Siemens Bros. and Co. (Limited), for mains	3,856
Messrs. J. and J. Horsfield, for boilers	2,998

APPOINTMENTS.—Mr. Proctor, who has been acting as clerk of the works for the erection of the Bristol Central Station, has been appointed Resident Engineer at a salary of £260 per annum; and out of 40 applicants Mr. A. W. Rankin had been appointed Assistant Engineer at a salary of £130 per annum.

——— Mr. A. E. Farrow has been appointed resident engineer for the Windsor Electric Lighting Company; and has already taken over the charge of the works in Goswell-lane.

PERSONAL.—Mr. Reginald J. Wallis-Jones has joined the staff of Messrs. Kincaid, Waller, and Manville, consulting engineers.

RESIGNATION.—The *Richmond Herald* states that Mr. Shoolbred, electrical engineer to the Richmond Town Council, has tendered his resignation.

REMOVAL.—The Glasgow branch of the General Electric Company has been removed from 79, West Regent-street, to 196, St. Vincent-street.

BANKRUPTCY.—William McWhirter, electrical engineer, of Campbell-street, Govan, Glasgow, was adjudicated a bankrupt on May 30th. Creditors are to meet in the Faculty Hall, Glasgow, this day (Friday) at 12.

MESSRS. BOURNE AND GRANT.—We are asked to insert the following:—"As some misapprehension appears to exist in consequence of the registration of the Bourne and Grant Electricity Supply Company (Limited), may we ask you to be good enough to allow us to state that the business of electrical engineers and contractors hitherto carried on by us is in nowise interfered with or altered by the creation of the Company, which is a distinct and separate concern."

DIRECT UNITED STATES CABLE COMPANY (LIMITED). A branch station has been established in Winchester House by this Company for the transmission of messages to and from North and South America. The new station is situated on the first floor, and is in direct communication with the Company's cables.

FIRE.—On Sunday a destructive fire occurred at the engineering works of Messrs. Alley and M'Lellan, Polmadie, Glasgow. The loss is estimated at about £10,000, which is covered by insurance.

MESSRS. NEW AND MAYNE'S TRANSFORMER SWITCH.—We have received a sketch and description of an automatic switch for cutting a transformer out of circuit when the last lamp is switched off the secondary, and for putting in again when a lamp is turned on. The apparatus appears on the sketch to be exceedingly complicated, but this is not necessarily a disadvantage. It consists of main switches on both secondary and primary circuits, the latter being provided with a spark-breaking shutter. Two trains of clockwork and three solenoids, besides an electromagnet, numerous contact pieces, and resistance coils are provided. When a lamp is switched on, the apparatus is so disposed that a primary battery sends a current

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through the distributing leads, and, by means of a magnet, works a train of clockwork, and pulls over a weighted lever which works the main switches and other contacts. The last lamp being turned off, a solenoid starts the other clockwork, which turns off the switches. We understand that the apparatus has been tried and found to work.

THE EDISON-SWAN COMPANY.—This Company are now in a position to undertake at their works in London, silver-plating, nickel-plating, and gilding of all descriptions.

TELEPHONES.—Mr. Kotyra, the agent in Great Britain for Messrs. Ch. Mildé and Co., has just issued a handy catalogue illustrating a large number of telephones and telephone accessories, for which the firm have for many years been celebrated. The illustrations include 31 different patterns, all of which are either patented or registered. It is claimed that the instruments are all of high-class workmanship, and specially suitable for the home and colonial markets. On page 21 a useful form of telephone "inkstand" is shown, and on page 20 a portable table combination. On page 22 is shown a telephone inkstand in highly-finished artistic brass work, and on page 23 the "manipulator" on a curved wood stand with switch and connecting plate. In addition, illustrations of trembling bells, indicators, tools, and pot cells are shown. The list can be obtained by the trade on application at the London office, 60, Watling-street, E.C.

THE PHOSPHOR BRONZE COMPANY.—We have received from this Company their new catalogue of phosphor bronze specialities. The list includes a number of illustrations, showing a variety of uses to which the Company's manufactures are specially adapted. A number of testimonials are included in the list, and several useful tables. Among the illustrations is one of a second-class torpedo boat, built entirely of rolled and drawn phosphor bronze plates and angles.

MESSRS WILCOX AND CO.—At all the principal agricultural shows throughout the country, including Chester, Norwich, and Tunbridge Wells, this firm are exhibiting a great variety of engineering specialities, for which they are well known throughout the trade, including packings, oils, engine and boiler mountings, hose, lubricators, belts, and an enormous variety of engineers' tools and general stores, specially suitable for employers of steam power.

ELECTRIC LIGHTING CONTRACT FOR RUSSIA.—Messrs. Mavor and Coulson have recently concluded a contract for electric lighting on a large scale in Russia. The place to be lighted is a woollen factory near St. Petersburg, the largest establishment of the kind in the country. About 6,000 16-c.p. lamps will be required, and the contract includes everything needed for the installation.

ABERDEEN.—The Gas Committee of the Town Council recommend the appointment of an Electrical Engineer at a salary of £200 per annum. It was decided that the Electrical Engineer should be under the superintendence of the Gas Manager.——The Directors of the Northern Co-operative Company have finally decided to introduce the electric light into their premises at Loch-street, and the Buildings Committee have the matter in hand.

BEDFORD.—The Urban Sanitary Authority have had under discussion the question of the tenders recently received for the electric lighting scheme. A complaint having been made by a member of the Board that these tenders had not been distributed amongst the members, a resolution was proposed asking that this should be done, accompanied by a report of the sub-Committee who had been appointed to inquire into the matter; but the matter fell through.

BELFAST.—The works in connection with the extensive installation of the electric light along the Queen's Quay are being rapidly pushed forward. The engines for the station are to be supplied and fixed by Messrs. Combe, Barbour, and Combe, and are to be fitted with Corliss valves. They are of sufficient power to drive a plant largely in excess of that at present being put down. The area of lighting is from the Queen's Bridge, along the Quay, round the Abercorn Basin, and on both sides of the Hamilton Graving Dock. Thirty-one are lamps of 2,000 c.p. are to be erected. Some difficulty has been experienced in placing the lamps, in order not to interfere with the traffic, or the loading and unloading of vessels, but the difficulties have now been overcome. Messrs. Siemens Bros. and Co. are the contractors for the work, and will also supply the lamps. In addition to the lighting of the quay, the Harbour Commissioners contemplate putting down an underground circuit for supplying incandescent lights on hire for vessels in the docks. Mr. George Combe, of Belfast, has charge of the electrical work, and Messrs. Giles and Kelly, the Harbour Commissioners' engineers, are superintending the erection of the engine-house and station.——Messrs. D. and G. Graham, of Glasgow, have just completed a large installation at the Grand Central Hotel, which was open to the public on Thursday last, and is one of the largest in the kingdom. The work has been done to the specification of Mr. J. H. Greenhill. The plant consists of two horizontal engines of 100 H.P. by Messrs. Sharpe, and two Galloway boilers of the same horse-power, and two compound-wound dynamos, each capable of supplying current for nearly 600 16-c.p. lamps. The total number of lamps is about 700, including four 1,500-c.p. arc lamps for the dining-room, which are in addition to four 6-light electroliers.

BRISTOL.—The Bristol Industrial and Fine Arts Exhibition, which it is proposed to open on August 28th, is now sufficiently forward in construction to allow of space being apportioned to intending exhibitors. Already a large area has been allotted, exceeding 12,000ft. Plans for the Industrial section of the Exhibition have been adopted, and considerable patronage is promised from local manufacturers and tradesmen. The building is to be lighted throughout by electricity, which is to be made a special feature. The fountain in the Fine Arts section is to be illuminated, and a search-light will be fixed on the front tower. At a meeting of the Electrical Committee of the Bristol Corporation a communication was received from the contractors for the building of the central station asking for an extra allowance in consequence of unpleasant difficulties encountered in laying the foundations. The Committee declined to receive the application. Mr. Preece stated that the works were well in hand, and would, he expected, be completed within three months. A question of lighting the Exhibition buildings was discussed, and the Committee were asked to undertake special lighting in the Fine Arts Department to illustrate the variety of the uses to which current can be applied. It was suggested that the principal electrical engineering firms would willingly participate in such an Exhibition, and the suggestion is to be discussed at an early meeting of the Committee.

CHELMSFORD.—The Town Council contemplate lighting the Shire Hall by electricity, and have asked the permission of the County Council for this purpose.

DOLGELLY.—We are asked by Messrs. A. Hall and Co. to state that the amount claimed by the Dolgelly Electric Light Company for damage to their lamps, claimed from the Local Board, is only a small amount, and that the Board did not refuse to pay this, but simply postponed their decision pending inquiry.

DUNDEE.—A statement has been issued by the Dundee Gas Commissioners showing the financial position of the electricity department. £20,000 has been borrowed, and there is a balance on loan capital of £10,000. The amount of £22,793. 19s. 4d. has been expended in connection with the works. Discussing these accounts, Mr. A. Brownlee, on behalf of the Committee, stated that the electric lighting installation was completed with the exception of the fittings, which had not yet come to hand.

FOREIGN OFFICE.—On Saturday last, the occasion of the public celebration of the Queen's Birthday, the Foreign Office was lighted by electricity. The crowd was very great, but notwithstanding this no inconvenience was experienced from the heat, as has previously been the case.

GLASGOW.—Amongst the recent contracts for electric lighting completed by Messrs. Anderson and Munro is the Western Club Buildings, where lamps of 200, 150, 32, 16, and 8 c.p. are included in the installation.

HACKNEY.—At the last meeting of the Board of Works, a report was presented by the Electric Lighting Committee notifiying that all the necessary Parliamentary notices and plans in connection with the Provisional Order had been prepared and submitted.

HANLEY.—Mr. Joseph Lobley, the Borough Engineer and Surveyor of Hanley, Staffs., has issued his report on the schemes for public street lighting within the compulsory area, accompanied by a short description of the works. The report is published in pamphlet form, and contains interesting details of the progress made with the work since the Provisional Order was obtained in 1891. In September, 1892, the Hanley Council accepted the tender of the Brush Company, amounting to £15 760. The site for the electricity works is conveniently situated near the centre of the area of supply and adjoining the canal, enabling the Council to obtain the necessary coal and water supplies on economical terms. A contract has been entered into for the erection of the necessary buildings for £2,990; with Messrs. John Warner for a 7-ton travelling crane; and with Mr. T. Cass, of Bolton, for three Lancashire boilers fitted with mechanical stokers.

HULL.—At the last meeting of the Electric Lighting Committee of the Corporation, Mr. F. Harman Lewis (who has just been appointed electrical engineer at Wolverhampton) tendered his resignation, which was accepted. It was agreed that advertisements should be issued for a successor to Mr. Lewis, at a salary of £270 per annum.

KELVINSIDE (GLASGOW). The applications for current from the Kelvinside Electric Light Company's mains represent about 4,000 lamps of 8 c.p. each, and already the question of putting down additional plant is being considered by the Directors. It is expected that two engines of about 120 H.P. each will be running in the

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course of a week or two. A number of large mansions in Kelvinside have been wired for some months, and are still awaiting current, and further wiring is in progress.

MADRAS.—It is stated that, owing to the severe conditions imposed by the Telegraph Department of the Government of India, the Directors of the Madras Electric Tramways Company have decided to adopt the conduit system, in lieu of the overhead system, for their tramways.

NANNERCH (WALES).—Messrs. Paterson and Cooper have just put down a large electrical plant at Penbedw Hall for lighting, motive-power, and heating. The installation consists of about 300 incandescent lamps distributed over the mansion, the stables, coach-houses, sheds, workshops, and cottages, covering about 30 acres. Eight motors are used for working the threshing machines, corn crushers, circular saws, sewing machines, &c., and the heating arrangements are adapted for use in the kitchens and dining-room. The plant includes a Brotherhood vertical compound engine, a Cochrane vertical tubular boiler, and a set of 108 L31 type E.P.S. accumulators. The work, which includes a complete system of electric bells and automatic calls, has been carried out under the superintendence of Mr. A. Marsden.

NEWPORT (MON.).—Alderman Davies, at the last meeting of the County Council, presented the report of the Parliamentary Committee, showing the steps taken to provide electric lighting for the borough. Prof. Robinson had sent in an amended estimate, showing a reduction of £5,000 on the previous figures. He stated that the Provisional Order expired this year, but the Committee were taking steps to secure the light being retained in the hands of the Corporation. The Council approved of the Committee's report.

ROCHDALE.—The Town Council, on the recommendation of the Health Committee, have accepted the tender of Messrs. Laing, Wharton, and Down, for the supply and fixing of the plant required for lighting the Sanitary Manure Works by electricity.

RUGBY.—With reference to a note which appeared in our last issue, we are asked by Mr. J. A. McMullen to say that the question of lighting at Rugby School has been definitely settled, and that on Wednesday, last week, the site for the generating station, situated behind the gymnasium, was approved.

ST. PANCRAS (LONDON, N.W.).—A report has been issued jointly by the Electricity and Public Lighting and Special Dusting Committees of the Vestry on the subject of combining the destruction of refuse with the production of electricity. The report states that there are many instances where waste heat from destructors has been economically used for generating electricity, and that the business of combining the two operations is being entered upon by many of the Local Authorities throughout the country. The Vestry's King's-road Station enables these operations to be carried out advantageously, as a demand exists for electricity in the immediate neighbourhood; and there is no doubt the station would at once take up the whole of the day load and the entire supply of the High-street district, together with 300 Clearing House lights, making 1,800 lights in all, which would be taken from the Stanhope-street station at once, enabling the latter to supply 1,800 further lights in its own district. The report recommends the scheme generally, and the Committees agree that the principle should be adopted. At the last meeting of the Vestry the report was discussed, and the debate upon it was adjourned until Wednesday next.

STAFFORD.—The Town Council have received a report from Mr. Bell, the manager of their gas enterprise, giving details and estimates of a scheme for electric lighting. The Electric Lighting Committee recommend the employment of an electrical expert to report upon the scheme to the Council, and this recommendation has been adopted.

TAMPERING WITH TELEGRAPH WIRES.—On the Derby-day two wires, the property of the Column Printing Telegraph Syndicate, were maliciously tampered with in London with the apparent object of preventing the Company's subscribers receiving the result of the Derby. A reward of £20 is offered for information leading to the conviction of the offenders, and it is pointed out that by the Telegraph Act, 1868, persons tampering with telegraph wires are liable to a term of imprisonment with hard labour.

THE ELECTRIC LIGHT IN MINES. The electric light is to be used in the Roodepoort Deep Level (South Africa)in order that continuous sinking may go on under the best conditions.

THE ROYAL UNITED SERVICE INSTITUTION.—The electric lighting of the large main building of this Institution, as well as of the temporary premises and marquees, has been carried out, to the plans and specifications of Mr. E. Wingfield Bowles, C.E., the consulting engineer, by the General Electric Power and Traction Company (Limited). The main hall is lighted by four large suspended pendants, each carrying five 100-c.p. lamps. Under the galleries pendants are fixed, carrying three lights, and on the gallery itself brass standards are used, each carrying three lights. The total actual candle-power for the main hall is 3,540, and for the temporary lighting 250 16-c.p. lamps are used.

TUNBRIDGE WELLS.—A meeting of the Ratepayers' and Owners' Property Association has been held, and a discussion ensued on the electric lighting question, introduced by Mr. Alderman Clifford, who hoped the town would carry out the Provisional Order they had obtained. He stated that, in response to circulars sent out, there had been already promised something like 1,500 lamps. He thought it would be unwise for the Town Council to hand over their rights to a private company. Another speaker (Councillor Putland) believed that if steps were not immediately taken, the local gas company would probably endeavour to obtain powers to introduce the light. Ultimately it was resolved to discuss the question again at the next monthly meeting.

WINDERMERE.—At Troutbeck Bridge an electric light plant has been put down by Messrs. Fell and Sons. A 27in. turbine is used, together with an Armington and Sims engine and Galloway boiler. A Mordey alternator generates the current. About 650 lamps are already connected.

WREXHAM.—At a recent meeting of the Lighting Committee of the Town Council the arrangement proposed by the Brush Company with reference to the Council's taking over the Provisional Order and powers of the Wrexham and District Electric Light Company was discussed. This arrangement includes the payment to the Wrexham Company of £500 for their rights, and the Brush Company undertakes to provide and construct the necessary station and works (other than actually in connection) within the compulsory area, and to transfer the works and plant to the Corporation, for £13,049. At the meeting, Mr. Paris, acting for the Brush Company, produced the various plans and specifications, and explained the system recommended for the installation, which he estimated would cost for maintenance about £1,200 per annum. A proposal to adjourn the discussion of the subject having been carried, a meeting was subsequently held (May 24th), at which a resolution was proposed recommending the Council not to proceed further with the negotiations. This was rejected, and the Committee recommended the purchase of a pamphlet by Mr. J. A. McMullen, for distribution amongst the members of the Committee. The matter will be again discussed at the next meeting of the Council.

WORCESTER.—It has been decided by the Guardians to invite estimates from three different companies for the supply of the electric light fittings required at the workhouse for the installation which is to be put down.

COMPANIES' MEETINGS.

Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited).

The fourth annual ordinary general meeting of this Company was held at the Cannon-street Hotel yesterday, Mr. F. L. Rawson presiding.

The CHAIRMAN said that the balance-sheet set out in detail the state of affairs. They would find a heading "Liabilities on securities of this Company in connection with loans to Elmore's French Company, £69,274. 18s." This was no money liability, but meant that these investments, which had been lent to the French Elmore Company for them to raise money upon, were out of their hands, and, if the French Elmore Company never paid a penny to any creditor, would be lost, unless they found a sum a little under £10,000 to redeem them. Part of these securities would probably be returned almost immediately; some later on. There was also another liability of £2,500, shown in the balance-sheet, upon the bills receivable discounted, for which the French Company were also primarily responsible. This liability he believed they had got rid of. With regard to the profit and loss account, the expenses were less than in previous years, being in all £2,924. 17s. 6d., as against £3,698 and £7,568 respectively. The balance of the profit and loss (£224,000) they must not assume was all profit, as the shares and debentures of the subsidiary companies were taken at par, and until the price of the shares of the subsidiary companies had risen, it could be merely treated as a balance. With regard to their interests in the French Elmore Company he hoped they would reap substantial benefit from the arrangements which had been come to, the terms of which were set out in the Directors' report (*see* page 163 of this issue). The Directors had been blamed by those interested in the French Elmore Company for not being more compliant in the matter of the settlement; but now that the position of the French Elmore Company was saved, he did not see why the Foreign Elmore Company should abate their rights one iota more than sufficient to enable the scheme to go through. On the other hand, the priority shareholders of this Company blamed them for having helped the French Company at all. In this case success had justified the Directors' policy. The success of the French Company, in addition to being of great value to the American Elmore Company, and to this Company also, would enable them to sell the Belgian and Italian patents, and they still had the patents for India and the Colonies, Russia, and other countries to dispose of

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NEW COMPANIES, STATUTORY RETURNS, &c.

BENHAM AND FROUD (LIMITED).—The annual return of this Company, made up to May 10th, recently filed, shows that 2,907 out of 5,000 shares of £10 each have been taken up, and the full amount called thereon. The calls paid amount to £28,887. 10s., while £182. 10s. remains unpaid.

BIRMINGHAM HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED). MIDLAND HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED). NORTHERN HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED). The annual returns of the above-named Companies, made up to January, 1893, have recently been filed. In each case the nominal capital is £100,000, divided into 19,900 ordinary and 100 founders' shares, the latter being issued to the parent Company, the House-to-House Company, of Richmond-road, London, S.W. In addition to these shares, the only ones taken are those subscribed for by the signatories to the Memorandum of Association, no calls being paid thereon.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The annual return of the Company, made up to May 17th, has been filed. The whole nominal capital of £1,300,000, in £10 shares, has been taken up, the full amount called, and the full amount paid.

ELMORE'S FOREIGN AND COLONIAL PATENT COPPER DEPOSITING COMPANY (LIMITED.).—The report states:—"The surplus for the year amounts to £224,083. 11s. 6d., after payment of all expenses and deducting £30,000 as the original value of the American and Canadian patents, sold in the course of last year. It will be noted that, as in the previous balance-sheet, all the shares and debentures are taken at par, it being impossible to judge of their real value at the present time. During the past year there have been various negotiations with regard to the sale of patents; but it has been impossible to conclude sales on terms that were at all advantageous to this Company, as none of the subsidiary companies were, until lately, in a position to show continuous working on a reasonably large scale. The Directors have pleasure in pointing out that their previous statements in regard to the successful practicability of the Elmore process are now borne out by the results of recent investigations and reports made by various experts, and by committees of the shareholders of the English and French companies."

LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 16th, has been filed, 37,548 shares of £10 each (out of a total of 40,000) have been taken up, the full amount called, and all calls (£375,480) paid. 800 shares have been forfeited.

MAQUAY SYNDICATE (LIMITED).—Claims against this syndicate (in liquidation) must be sent in to the liquidator, Mr. T. Rawlins, 45, King William-street, E.C., by July 8th. A first and final dividend will, we understand, shortly be announced.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of this Company, made up to May 5th and recently filed, shows that the whole nominal capital of £500,000, divided into 49,900 ordinary shares of £10 each, and 100 founders' shares of like value, has been taken up. 2,132 shares have been issued as fully paid, while the full amounts have been called on the remaining 47,868 shares. The calls paid amount to £478,421. 9s., while £258. 11s. is as yet unpaid.

MEXICAN GAS AND ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of this Company, made up to November 9, 1892, and recently filed, shows that the whole nominal capital of £100,000, in £20 shares, has been issued as fully paid to Alban G. H. and Herbert C. Gibbs, of 15, Bishopsgate-street Within, London, E.C. (4,993 jointly), and their seven nominees.

MOUNTAIN'S WIRE MANUFACTURING COMPANY (LIMITED).—The first meeting of creditors of this Company (being wound up) will be held at the offices of the Official Receiver, St. Andrew's-chambers, 22, Park-row, Leeds, on Wednesday next, at 11 a.m., and the first meeting of contributories will be held at the same place on the same day at noon.

NEW ZEALAND ELECTRICAL SYNDICATE (LIMITED).—The annual return of this Company, made up to November 11, 1892, has recently been filed. Out of a nominal capital of £30,000 in £10 shares 2,955 shares have been taken up, of which 200 were issued as fully paid to the Gülcher (New) Electric Light and Power Company (Limited). Upon the remaining 955 shares the full amount has been called. The calls paid amount to £6,350, leaving £3,200 in arrears.

YORKSHIRE HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED).—The annual return of this Company, made up to May 26th, has been filed. Out of 19,900 ordinary and 100 founders' shares of £5 each, 7,328 ordinary and 100 founders' shares have been taken up, of which the founders' shares have been issued as fully paid to the promoting company, the House-to-House Electric Light Supply Company (Limited). Upon the 7,328 ordinary shares a call of £4. 10s. per share has been made, resulting in the payment of £32,530, and leaving £592. 10s. unpaid.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended June 4th were £914, as against £782 for the corresponding period of last year, being an increase of £132. The total receipts for the half-year amount to £19,493, against £17,869 in the corresponding period of 1892, being an increase of £1,624.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of May are £3,700, as compared with £3,672 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY.—The gross receipts for the month of May were £1,866, as compared with £2,132 for the corresponding period of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—In our last number we gave particulars of the issue by the Eastern Telegraph Company of £200,000 £4 per Cent. Registered Mortgage Debentures (Mauritius Subsidy) of the Eastern and South African Telegraph Company (Limited). We learn that this issue, the subscription for which closed on Wednesday last, has been subscribed more than twice over.——The traffic receipts of this Company for the month of May amounted to £57,946, and to £54,842 in the corresponding period of 1892, an increase of £3,104.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of the Eastern Extension, Australasia and China Telegraph Company (Limited) for the month of May, 1893, amounted to £45,395 and to £40,612 in the corresponding period of 1892; increase, £4,783.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).—The Directors recommend the payment on July 1st next of the following dividends:—On the ordinary shares at the rate of 30 per cent. per annum on the capital paid up for the six months ended May 31st last, making, with the interim dividend already paid, 25 per cent. for the year; and on the founders' shares £30 per share.

ELMORE'S FRENCH COPPER DEPOSITING COMPANY (LIMITED).—Mr. Justice Vaughan Williams on Wednesday pronounced a compulsory winding-up order against this Company; but subsequently, it appearing that the petition had been made in the belief that it was unopposed, withdrew the order, and directed the petition to stand over, with a view to arrangements said to be for the benefit of the creditors being arrived at.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this Company for May amounted to £24,000, and from January 1st to May 31st to £108,000. In the corresponding months of 1892 and 1891 the amounts were £104,800 and £114,000 respectively.

MALTA AND MEDITERRANEAN GAS COMPANY.—Speaking at the ordinary general meeting of this Company, held on Tuesday last, the Chairman (Mr. John Birch Paddon) referred to the increased cost of coal and the decreased price of residuals, and the competition of electric light. He said that "with regard to the competition of the electric light I think that it may be said that, so far, it has done us no harm whatever, but inasmuch as there may be some competition, I think it right to mention two reasons why such competition can have no very great importance. In the first place there is this, that the cost of the electric light in Malta is quite three times that of gas, and consequently the persons who use the electric light there will be the persons to whom the cost is a matter of no importance, and there are not many such persons in Malta. Then the next thing is that there are no known ways of satisfying the consumer of the electric light that he is receiving the volume of light for which he has to pay. Now, thrifty people like to get the full value for their money, and the Maltese people are thrifty in the best sense of the word. Until some reduction in the cost of the electric light is effected, so as to bring it down to the cost of gas—and it is worth no more—and until some approach is made for commercially regulating the measuring of the electric light, I think that we may consider anything like permanent competition from it is out of the question, and whatever installations may be put up will only be a temporary detriment to the gas companies. As regards public electric lighting in Malta, application has been made to the Council of the Government to establish an installation for electric lighting, but the elected members of the Council are adverse to any expenditure of any part of their funds in speculative purposes, and therefore nothing whatever has been done."

MORGAN CRUCIBLE COMPANY (LIMITED).—Mr. O. V. Morgan has retired from the Board of this Company.

NORTHERN ASSURANCE COMPANY.—The report for 1892 shows that in the fire department the net premiums amounted to £710,762, an increase of £21,464 over those of the previous year. The net losses were £480,100, and the total expenses of management, including commission, were £233,895, the year's operations, after making the usual provision for liability under current policies, resulting in a loss of £10,388. The total accumulated funds of the Company on December 31, 1892, amounted to £4,146,419.

PANULCILLO COPPER COMPANY (LIMITED).—At an extraordinary general meeting, held on Friday, it was resolved to voluntarily wind up the Company. Sir John Pender, G.C.M.G., M.P., who presided, said that the Directors would, before the holding of the confirmatory meeting, submit proposals for reconstructing the Company and developing the property.

OXFORD ELECTRIC COMPANY (LIMITED).—The Directors of this Company announce that Five per Cent. First Mortgage Debentures of £50 each, payable to bearer, being part of a total issue of £25,000, are offered for sale at par. Nearly the whole of the capital for this enterprise has been found by the Electric Construction Corporation (Limited), the debentures now offered being the first opportunity the public have had of obtaining an interest in the undertaking.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED.)—The receipts for the two weeks ended May 31st were £3,655, as compared with £3,215 for the corresponding period of last year.

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STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to appoint a special settling-day in, and to grant a quotation to, £50,000 Five per Cent. First Mortgage Debentures in Crompton and Co. (Limited).

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended June 2, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,438.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name	Previous Week's Price, May 31.		Price Wednesday, June 7.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 7.	
								£ s. d.		Highest	Lowest
			TELEGRAPHS								
£1,247,720	Stock	12/6	Anglo-American	50½	51½	49½	50½	5 8 11	Jan., Apr., July, Oct.	50	..
£2,876,140	Stock	25/0	Do. Preferred	92	93	91½	92½	5 18 11	" "	92⅞	91⅞
£2,876,140	Stock	5/0	Do. Deferred	11¼	11⅜	11	11⅛	..	" "	11⅛	11⅛
£250,000	100	4%	African Direct, Telegraph 4% Debentures	101	104	101	104	3 16 11	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11⅛	12	11⅞	12¼	5 6 1	Mar., June, Oct., Dec.	12	11⅞
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107	111	107	111	4 10 1	June and December	..	..
£7,716,000	$100	$1⅜	Commercial Cable Capital Stock	140	150	140	150	4 13 4	April and October	..	..
16,000	10	8/0	Cuba Submarine	11½	12½	11½	12½	6 8 0	February and August	12½	11⅛
6,000	10	10%	Do. Preference 10%	18½	19½	18½	19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½	3½	2½	3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅛	11⅞	11⅝	11⅞	5 18 2	Jan., Apr., July, Oct.	11⅞	11⅛
400,000	10	2/6	Eastern	15⅛	15⅝	15⅝	15⅝	4 4 6	" "	15⅝	15⅝
70,000	10	6%	Do. 6 per Cent. Preference	16½	17	16⅝	17	3 10 7	" "	17	16⅝
£1,294,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112	115	112	115	3 9 7	May and November	114¼	112½
£105,900	100	5%	Do. 5 per Cent. Debentures 1899	108	111	108	111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	15⅝	15⅞	15⅝	15⅞	4 8 2	Jan., Apr., July, Oct.	15⅞	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	111	114	112	115	3 9 7	February & August	113⅝	113
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	103	106	104	107	4 13 6	January and July	105½	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb., 1900	103	106	103	106	4 14 4	" "	104⅝	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101	104	101	104	3 16 11	February & August	102⅝	..
180,227	10	2/3	Globe Telegraph and Trust	9⅝	9⅞	9⅝	9⅞	4 11 2	Jan., Apr., July, Oct.	9⅞	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	15½	15⅞	15½	15⅞	3 16 2	" "	15 15/16	15½
1 0,000	10	7/2	Great Northern	19½	20	19½	20	4 5 0	Jan., April, and July	19 11/16	19½
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	107	106
17,000	25	37/6	Indo-European xd and Bonus	40	43	40	43	5 16 3	May and November	41	40½
38,348	10	4/0	London Platino-Brazilian	4	6	4	6	6 13 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent Debentures	106	109	106	109	5 10 1	March & September	..	..
100,000	100	4%	Pacific European Tele. 4 per Cent. Guar. Debs.	101	104	101	104	3 16 11	.. ..	..	..
10,802	8	4/0	Reuter's	7	8	6½	7⅜	..	April and October	..	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6%	119	124	119	124	4 16 9	" "	119½	..
15,609	10	5/0	West African Telegraph	5½	6½	5½	6½	7 13 10	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100	103	100	103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	3	4	3	4	..	January and July	3⅜	3⅛
£150,000	100	8%	Do. Debentures 8% 1902	103	107	103	107	7 9 7	June and December	..	..
88,321	10	6d.	West India and Panama xd	1⅛	1⅜	1⅛	1⅜	..	..	1 3/16	..
34,563	10	6%	Do. 6 per Cent. 1st Preference xd	11½	11⅝	11	11½	5 4 4	May and November	11⅝	11
4,669	10	6%	Do. 6 per Cent. 2nd Pref. xd	9½	10¼	9½	10½	5 14 3	" "	9½	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	108	111	108	111	4 10 1	June and December	..	..
64,242	15	4/6	Western and Brazilian	7¼	7¾	7½	8	4 13 11	May and November	7⅞	7½
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5½	6¼	6	6½	5 15 3	..	6 5/16	6⅛
33,129	7½	4/6	Do. 5 per Cent. Deferred	1⅞	2¼	1⅞	2¼	..	..	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 10 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106	109	106	109	5 10 1	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	..	..
£173,100	£100	6%	Do 6 per Cent. Sterling Bonds	100	103	100	103	5 16 6	March & September	102¾	..
			TELEPHONES.								
40,000	£5	10/0	Chili Telephone (fully paid)	1⅛	2⅛	1⅛	2⅛	..	..	..	..
224,800	14/0	1½d.	Consolidated Telephone Const. & Maintenance	3/16	5/16	3/16	5/16	..	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	⅛	¼	⅛	¼	..	Yearly	..	..
454 747	5	2/6	National	5	5½	5⅛	5⅝	7 18 2	June and December	5⅝	5½
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14⅜	15½	14⅜	15½	5 11 7	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14½	14⅝	14½	14⅝	3 18 8	" "	..	..
90,950	5	6⅜d.	Do. 5% Non-Cumulative 3rd Pref. (£3 paid)	5⅜	5⅝	5⅜	5⅝	4 1 4	.. ..	..	..
726 477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	112	115	112	115	..	..	5 9/16	5⅜
48,000	£10	..	New Telephone, Limited (£4 paid)	..	..	..	..	3 18 3	January and July	114	..
58,000	5	1/0	United River Plate	2	3	2	3	..	..	..	..
	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	..	January and July	..	..
								5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (fully paid)	12	12½	11¼	12	..	–	..	..
20,000	£10	..	Do. 6 per Cent. Preference (£4 paid)	12½	13	12⅛	13	..	..	13	12⅞
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	–	–	–
£150,000	£5	..	Electricity Supply Company Ordinary	5	5½	..	..	..	..	..	..
£47,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	–	..	..
8,332	£5	..	House to House Electric	1½	2½	..	..	..	–	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully pd.)	5⅜	5⅝	..	..	..	..	–	–
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	6	6½	..	..	..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4½	4⅝	4½	4⅝	..	..	..	..
10,000	£5	5/0 '92	Do. (fully paid)	6½	6⅝	6⅜	6⅝	..	..	..	..
111,000	5	..	London Electric Supply	⅞	1⅛	..	..	..	..	..	..
43,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6	6½	6	6½	3 1 6	June and December	6 5/16	..
£50,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, & £40)	103	106	101	104	4 16 2	" "	104	..
36,318	10	..	Notting Hill Electric Lighting (fully paid)	5	6	5	6	–	–	..	..
18,680	£5	9½%	St. James' and Pall Mall	7⅞	8	7¼	7¾	..	–	7 11/16	..
7,900	£5	7%	Do. 7% Preference	8	8½	8	8½	4 2 4	–	8⅜	..
42,853	5	2/0	Westminster Electric Supply (fully paid)	5½	5¾	5¼	5¾	3 0 10	–	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/6	Brush Electrical Engineering	3⅛	3⅜	3⅛	3⅜	..	–	3 3/16	3⅛
69,996	2	6%	Do. 6 per Cent. Preference	2⅛	2⅜	2⅛	2⅜	5 1 1	–	2 5/16	2⅛
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	108	110	108	110	4 1 0	..	..	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼	5⅜	5¼	5⅜	6 1 9	January and July	5 5/16	..
12,139	5	..	Edison and Swan United	..	..	..	..	..	–	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..	..	..	..	..	–	..	..
45,000	10	12/0	Electric Construction	2	2⅛	2	2⅛	..	–	2⅛	2⅛
70,000	2	10/0	Elmore's Patent Copper Depositing	⅜	⅝	⅜	⅝	..	–	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1	2	1	2	..	–	1⅜	..
50,000	10	15/0	India Rubber, Gutta Percha &c., Works	22½	23½	22½	23½	5 6 4	February & August	23½	22½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	2½	3½	2½	3½	..	..	..	..
11,334	£10	8/0	Do. Preference	..	..	..	..	..	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	5/0	6/0	5/0	6/0	..	..	..	..
78,949	5	4/2½	Swan United (£3. 10s. paid)	3	3½	2½	3	13 8 4	May and November	2⅞	2⅝
37,350	12	24/0	Telegraph Construction and Maintenance	30	32	31	33	5 9 1	March and July	32	31
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102	105	102	105	4 15 3	January and July	104½	..
..	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	..	..	..	..	..	–	–	–
..	£5	..	Do. Preference (fully paid)	..	..	..	..	..	–	–	–
			RAILWAYS AND TRAMWAYS.								
63,000	£10	..	City and South London Railway	..	..	..	..	..	..	..	..
600,000	Stock	5%	Do. Stock	37	39	37	39	2 17 8	May and November	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 787.—Vol. XXXI. FRIDAY, JUNE 16, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

If the statements contained in M. Haubtmann's article, which will be found in another column, are correct, the decision recently given by the Court of Appeal in France in connection with the Faure accumulator patent is yet another instance of the vagaries of patent law, not in this country alone but all the world over. According to M. Haubtmann's reading of this remarkable decision, anyone who makes use, in no matter what way, of lead oxides or salts in the manufacture of accumulators is an infringer of the Faure patent. The brief history of the question prior to Faure's patent of 1880 given by M. Haubtmann is sufficient to show the tremendous extension of scope that has been given to this patent.

It is evident that the remedy for all the ills the patentee and manufacturer are heirs to does not consist merely in having expert assessors on the bench. In this action the experts and their report were very much in evidence, but the Court, nevertheless, gave judgment in a contrary sense. Hence these tears, and the demand of M. Haubtmann that a patent should be granted for an original and particular *process of manufacture* regardless of the existence of a patent for a general method. To take a concrete case. If A took out a patent for mechanically applying butter to bread, using preferably a spoon, M. Haubtmann's contention is that B should be given a patent for buttering bread with a knife. This would certainly mean death to master patents and to the patenting of embryonic ideas, which at present give so much employment, respectively, to lawyers and patent agents.

In printing the concluding portion of Mr. Nikola Tesla's lecture we must remind our readers that it is but a brief abstract of the original, as is indeed indicated by the numbering of the figures, seventeen of which we have had to omit. Those who are specially interested in the experiments, and in Mr. Tesla's speculations, should consult the full text of the lecture, which will be found complete in the *Electrical World* of New York of June 3rd.

Mr. Nikola Tesla has, we believe, a great respect for Prof. Dewar and his work, and it is, therefore, greatly to be regretted that he should, on the strength of mere newspaper accounts, suppose that Prof. Dewar has either suggested or has given the smallest support to the idea that a vacuum is opaque to radiant heat. Mr. Tesla describes an experiment with an incandescent button surrounded by two globes of glass; the outer globe remained cool so long as a vacuum was maintained between these globes, by a pump, but after sealing off, the outer globe became warmed. "From this I conjectured," says Mr. Tesla, "that if vacuous space (as Prof. Dewar finds) cannot convey heat, it is so merely in virtue of our rapid motion through space, or, generally speaking, by the motion of the medium relatively to us, for a permanent condition could not be maintained without the medium being constantly renewed. A vacuum cannot, according to all evidence, be permanently maintained around a hot body." This mare's-nest was started in *The Times*. As a specimen of daily newspaper science it was not more absurd than usual. The writer had evidently attended Prof. Dewar's lecture, and not content with reporting what he saw and heard, started the "opaque vacuum" theory. Prof. Dewar had no responsibility in the starting of this notion. So long as it remained a matter for newspaper discussion no harm was done, but if men of Mr. Nikola Tesla's standing are going to be misled by it, it is time that Prof. Dewar made a statement on the subject. We are not sure, however, that this would at once dispel the fallacy; it offers such a capital subject for writers of magazine articles.

The Perry meter has at last been put on the market. We gave a full account of an early form of this instrument in *The Electrician*, Vol. XXVII., p. 191. From that description it was evident that the meter gave promise of eclipsing all other kinds of continuous-current meters, in respect of true proportionality, temperature error, and range. How far Messrs. Johnson and Phillips, who have taken up the manufacture, have succeeded in retaining the theoretical features while the instrument has been reduced to a practical form, we are unable to say. We have received from them a calibration curve of a 60-ampere meter. The lowest reading on this curve is 2·5 amperes, and the "curve" is certainly a straight line from this point up to 60 amperes. We are informed that this meter starts at 0·09 ampere. The readings between this and 2·5 would be interesting. The limits of most meters are the starting current at one end of the range, and departure from proportionality, or over-heating at the other. Even meters of the Aron type, when provided with a synchronising arrangement, have a starting current. We presume that as the motion of the Perry meter is so slow, this being the important feature by which mechanical friction is minimised, its upper limit depends on heating.

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The suggestion made by a correspondent for the improvement of the pupil system is hardly likely to commend itself to firms who receive pupils. He proposes that a workshop instructor should walk the shops, answer all questions, and give all needful instructions. To this omniscient individual the premium of one of the pupils is to be devoted, and this is put at £100 a year. A man who could answer one-half even of the reasonable questions, and could give one-half of the necessary instruction in all the shops, would be worth a good deal more than this to the firm. One of the greatest advantages of the pupil system is that the professor, the demonstrator, and the instructor, invaluable in their proper places, are absent. The pupil has to think for himself, not to be thought for, and to use his wits, not text-books. Judicious expenditure on drinks is indispensable; the pupil must learn this as part of his training for his future profession.

The general idea of our correspondent, Mr. W. S. Boult, in his letter which we publish elsewhere, is one which is quite in agreement with the experience of central-station engineers. The use of storage cells *does* assist the station to a more satisfactory day load, and brings about a better load factor; but their use must be properly undertaken, otherwise it becomes a case of penny wisdom and pound folly. Storage batteries plant requires more experience and skill in attendance than any other part of an electrical supply plant, and this can only be effectively given by grouping many cells into large sub-stations. To put cells into each consumer's house, or to have a large number of small capacity batteries, taking power at from 100 to 500 volts and supplying it to lamps, would be disastrous; disastrous as to capital outlay, as to the high rate of depreciation (much higher than 7½ per cent.), and the net efficiency of distribution, which would probably be almost worse than anything that has yet been published. Is our correspondent prepared to guarantee, or does he know of any electrical firm prepared to guarantee, small storage plant with unskilled attendance at 7½ per cent. of cost for repairs? The E.P.S. Company make a charge of from 10 to 20 per cent. for this purpose, under special conditions. And where shall we get such a small battery fixed in our house for £2 per lamp? By a curious coincidence, almost an identical suggestion is made by a correspondent of the *Gas World*, who proposes small gas-holders in private houses. Were, however, the available means of electric storage as perfect as in gas works, the whole business would be revolutionised, alternating currents would pass into ancient history, and the price of electric supply would fall considerably below that of gas.

A proposal which has been made to the Tiverton Town Council by Mr. Heathcoat-Amorey is one that we feel sure electric lighting contractors will approve of. The Town Council has been for some long time "thinking of going in for electric lighting," but financial considerations forbade anything more. Mr. Heathcoat-Amorey, however, public-spiritedly proposes that the inhabitants of Tiverton who really require the electric light should guarantee the Town Council against possible loss by agreeing to take electricity at 9d. a unit until the concern pays, the difference between 9d. and 6d., the normal working price, to be refunded to the guarantors as soon as the balance-sheet permits. The proposal is to be considered by the Electric Lighting Committee. If the suggested guarantee society ever gets to work on these terms, the inhabitants of Tiverton will have to be congratulated on having done something original and enterprising.

Whenever an electrical engineer happens to have had more than enough of the many phases of the alternate-current controversy, he cannot do better by way of antidote than betake himself to the serried columns of straightforward small type to be found in any journal devoted to the gas industry. There, at any rate, the typical higher harmonic and the double-distilled integral will cease from troubling. It was, therefore, with considerable alarm that a few days ago we came across an article in a gas contemporary, with the startling heading, "The Mathematics of Washers and Scrubbers." It was, however, a false alarm; as it is with the snakes in Iceland, so it is with washing and scrubbing mathematics: there are none. Makers of scrubbers and washers are, it appears, in an unregenerate state, and arrive at the proper dimensions of their interesting apparatus by guesswork "founded upon practical experience." Happy makers!

Bolton.—The special sub-committee of the Town Council have adopted the high-pressure alternating system, with four transformer sub stations.

Cable Interruptions: —

	Date of Interruptions.
Paramaribo-Cayenne	April 15th.
St. Thome-Loanda	May 30th.

Worcester.—A letter has been received from the Local Government Board sanctioning the loan applied for for the purpose of electric lighting.

Electricity in Japan.—We learn, says *Industries*, that the Japanese War Department has decided to adopt electric lighting at the various fortifications on the coast of Japan.

Royal Society.—The following Paper was down for reading yesterday at the Royal Society:—E. H. Barton: "Electrical Interference Phenomena, Somewhat Analogous to Newton's Rings."

Yarmouth.—The Local Government Board will hold an inquiry on Monday next into the electric light scheme of the Town Council, involving an outlay of some £15,000. The inspector will be Mr. F. H. Tulloch.

British Iron Trade Association.—We are requested to state that a Conference of the Iron and Steel Trades will be held at the Westminster Palace Hotel, on Thursday, June 29th, at 11 o'clock forenoon, when Papers will be read and discussed.

Institution of Electrical Engineers.—We are requested to state that as the hat and coat accommodation is very limited at the Galleries of the Royal Institute of Painters in Water Colours, it will be very desirable that gentlemen attending the President's *soirée* on the 23rd inst. should bring either crush or felt hats.

Obituary.—The death is announced of Mr. H. Hunton, of the electric telegraph department of the North-Eastern Railway, which occurred, after a short illness, on Wednesday last week. The deceased was for over 28 years with the North-Eastern Railway Company. Prior to his services under the Railway Company, he was with the British Magnetic Company.

The Telephone Dispute at Broughty Ferry.—At the meeting of the Broughty Ferry Police Commission on Monday last it was reported that the National Telephone Company had made an offer of £25 per annum for existing wayleaves, and 1s. yearly

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at Whitsunday per pole on the streets, together with use of one instrument free and one at half rent. The Company's terms were accepted.

Errata.—Herr J. Fischer-Hinnen points out the following slips which occur in our abstract of his article on armature reactions, which appeared in *The Electrician* for May 26th, p. 104:—In Fig. 3 read "$2a$" instead of "a." In equation (3) read "L_3'" instead of "L'." Immediately above Fig. 7 read "a correspondingly strong *compensation* winding" instead of *magnet* winding."

Electro-Motors for Printing Presses.—We have received a copy of the *Galway Express* for June 10, 1893, which is the first newspaper printed by electric power in Ireland. The power is obtained from the 110-volt lighting circuit, and is supplied to that circuit from dynamos driven by water power. Electricity is sold in Galway at 5d. per unit for lighting and 3d. per unit for motive-power.

The Telephone Tubes in the City.—At the last meeting of the Commissioners of Sewers the Streets Committee presented a report with regard to the proposed use for telephonic purposes of certain of the tubes laid by the City of London Electric Lighting Company, and asked that further time should be given in order to consider the matter in connection with a communication from Mr. H. S. Foster, M.P. The recommendation was agreed to after some discussion.

The Azores Cable Contract.—The committees of the Departments of Public Works and Finance, appointed to consider the proposals of the Telegraph Construction and Maintenance and the Eastern Telegraph Companies for laying a cable from Lisbon to the Azores, with exclusive power to connect the Azores with England, Ireland, and other points in Europe, and with North America and Cuba, presented their report to the Cortes on 10th inst. Their decision was in favour of the proposals, and the Concession having been approved by the Chamber and House of Peers, was to be signed by the King yesterday.

Lightning Fatalities.—Two lives were lost by lightning in the townland of Barracliaring, parish of Donoughmore, on Friday evening last. Men were scattered all over the turf mountain, which extends for miles in the Donoughmore district, engaged in saving turbary, when about four o'clock a terrific hailstorm took place. When the hail ceased the thunder began, and two men were struck by lightning and instantly killed, while a third had a narrow escape. Near New Ross a girl was killed by lightning in a field, and a similar fate nearly overtook a man who was ploughing. He was severely injured by the lightning, while the two animals with which he was working were killed. On Sunday night at Swinford (County Mayo), a rainstorm set in, accompanied by thunder and lightning, and a farmer was killed.

The British Electric Light Company and the Newmarket Local Board.—The Board of Trade have issued a special report, with regard to the application made by the British Electric Light Company for a Provisional Order in respect of the district of the Newmarket Local Board. The Company were unable to produce the formal consent of the Local Board to the grant of the Order, and requested the Board of Trade to dispense with such consent. The report states that on the Local Board being informed that the Board of Trade proposed to dispense with their consent and grant an Order, the Local Board replied that, beyond objecting to the erection of overhead wires and to the opening of the streets during race weeks, they had no cause to show why their consent should not be dipensed with. The Board of Trade thereupon inserted a provision in the Order prohibiting the undertakers, except in cases of emergency, or with the consent of the Local Board, from breaking up or interfering with any street during the days fixed for race meetings.

Institution of Civil Engineers.—The following are some of the awards made for original communications submitted during the past session of this Institution:—For Papers read and discussed at the ordinary meetings, a Telford Medal and a Telford Premium were awarded to the late Mr. Willans (who had previously received a Watt Medal and a Telford Premium) for his Paper on "Steam-engine Trials"; and a George Stephenson Medal and a Telford Premium were awarded to Dr. Edward Hopkinson (who has previously received a Telford Medal and a Telford Premium) for his Paper on "Electrical Railways: the City and South London Railway." For a Paper printed in the *Proceedings* without being discussed, a Telford Premium was awarded to Mr. Charles Sheibner du Riche Preller for his account of the "Zurich Water-Supply, Power, and Electric Works." Mr. Preller has previously received Telford Premiums. For a Paper read at the supplemental meetings of students, a Miller Prize was awarded to Mr. Francis Gibson Baily for his Paper entitled "Some Points in the Regulation of Direct-Current Motors."

Fareham.—At the last meeting of the Local Board the members received a letter from the Fareham Gas Company asking that the Board would accept a tender from the Company for lighting for one or more years. The Lighting Committee reported that they were instructed by the Directors of the Fareham Electric Light Company that they would be pleased to renew the contract for light for three years on the same terms and conditions as specified in the existing contract, to supply current for 20 arc lamps and 92 incandescent lamps for £549 per annum, and one extra incandescent lamp on Wallington Bridge for £4. Mr. Drewitt said that the Lighting Committee were quite unanimous in their desire to see the town lighted with electricity for a further term of three years. He proposed that they should accept the tender of the Electric Light Company. Mr. Porter said he was of opinion that the town had been paying too large a sum for the electricity which had been supplied. He moved: "That tenders be invited for lighting the town and district of Fareham for one year, with electricity, gas, or oil, according to specifications to be drawn up by the surveyor." The motion of Mr. Porter, not being supported, was lost; and on Mr. Drewitt's proposition being put to the meeting it was carried.

The City Lighting.—At the meeting of the Common Council last week Mr. Altman said he desired to ask the Chairman of the Commissioners of Sewers whether any provision was made in the electric lighting contracts with reference to the supply of electricity to private consumers, a large number of whom some two years ago fitted their premises with the necessary appliances. Mr. Bridgman said: The three contracts entered into by the Commissioners of Sewers in relation to electric lighting related primarily to the public lighting of the streets in the City, but the clause in each of the contracts giving the wayleave for the private lighting mains provided that the contrators should supply electricity to any owner or occupier of property within a distance of 25 yards of the main within a reasonable time after the main was laid down. The remedy of owners or occupiers of property failing to obtain a supply of electricity was provided by the Provisional Order obtained by the contractors in respect of the district in which the property was situated. In addition to providing for the lighting of property on the main thoroughfares, each of the three Orders affecting the City required the undertakers, after the expiration of 18 months from the commencement of the Order, to lay down suitable and sufficient mains for the purposes of general supply upon being required to do so, in the manner provided by the Order.

Trunk Telephone Lines.—On Monday, in the House of Commons, Sir J. Fergusson asked the Postmaster-General what progress had been made under the Telegraph Act, 1892, in the acquisition of the trunk lines of telephones from the companies, in the construction of additional lines, and in the delimitation of the exchange areas. Mr. A. Morley replied that there had been some delay in carrying out the arrangements which were the subject of discussion before the late Government left office, due partly to the death of the late Duke of Marlborough, who was one of those who conducted the negotiations on behalf of the telephone companies. Considerable progress had, however, now been made, and the delimitation of the exchange areas had been practically completed. He trusted that the transfer of the trunk lines of the companies to the Post Office would not be long delayed. The construction of seven additional lines by the Post Office, including a submarine telephone cable to Ireland, had been completed, and progress has been made with the construction of main lines from London to twelve towns in the north, including Glasgow and Edinburgh, and from South

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Wales and the south-west of England to the coal ports on the north-east coast. These works were of considerable magnitude, and he did not anticipate that they would be completed before the end of the financial year.

Arago.—On Sunday last was unveiled a statue of Arago, erected in front of the Paris Observatory. Arago, who was born in 1786, and died in 1853, was elected a member of the Académie des Sciences when only 23. To Arago is due the discovery of the electro-magnetic phenomenon (once known as "Arago's rotations") of a metal disc rotated under a magnetic needle dragging the latter round with it, and a magnet revolved under a disc dragging the disc round with it. In September, 1820, Arago discovered that a wire traversed by an electric current attracted iron filings, and that he could permanently magnetise a steel needle by placing it at right angles to a wire traversed by an electric current. He greatly promoted the general acceptance of the undulatory theory of light, and established the connection between the appearances of the *aurora borealis* and terrestrial magnetic disturbances. Arago was an indefatigable propagator of scientific ideas. It was at his suggestion that a chair of popular astronomy was founded at the Paris Observatory, and in 1812 he commenced a series of popular astronomical lectures that attracted all Paris. In 1816 he and Gay Lussac founded the *Annales de Chimie et de Physique*, and later on he started the *Comptes Rendus*. In 1830 he became head of the Observatory and Perpetual Secretary of the Académie des Sciences. He subsequently became mixed up in the stormy politics of the day.

Three-Ton Electric Crane.—An electric crane is now at work on the Southampton Town Quay unloading vessels of the Clyde Shipping Company. A second crane will be erected very shortly. For lifting, a "Statter" motor, taking 200 volts and 225 amperes, at 600 revolutions per minute, is used. This motor runs continuously, and drives through worm and worm-wheel, the former running in an oil bath. In regular work, lifting 10 to 20 cwt. loads, the average current taken by this motor is about 50 amperes. To lift and lower, the worm wheel is put in and out of gear with the barrel by means of a "Lindsey" transmitter, worked by a lever placed on the driving platform. A powerful band brake is provided, and operated by a foot lever; and, in addition, there is a magnetic brake, which acts and holds the load in case the supply of current to the crane should cease at the moment that the load is being lifted. The average current required to slew is from 15 to 20 amperes. The current for driving the cranes is supplied by the Southampton Electric Light Company, and is fed through special mains laid along the Quay to a pair of overhead conductors of silicium bronze wire. The cranes have been constructed to the specification of Mr. J. G. W. Aldridge, the electrical engineer to the Harbour Commissioners, by Messrs. Statter and Co., working in conjunction with Messrs. Stothert and Pitt, to whom was entrusted the building of the gantries and the crane gearing.

Central London Railway.—Colonel Haywood has just made a report upon the application and plans of the Central London Railway Company for the construction of a station fronting the Mansion House. The plans show altogether seven staircases in connection with the subways and the railway station. The principal access to the subways and station will be by two staircases on the western front of the Royal Exchange, and another at the junction of Queen Victoria-street with the Poultry. The two Exchange staircases will be always open; all the others are to be so constructed as to be easily closed up. It is intended that there shall be a double staircase—one for the up and the other for the down traffic—in front of the London, Liverpool, and Globe Insurance office. Two staircases of a similar character will be made at the junction of Princes-street with Mansion House-street. Another staircase for a similar purpose will be formed in Mansion House-place, and will occupy the whole of the present footway at the spot, and the existing footway next to the Mansion House will, therefore, be permanently removed. Colonel Haywood states that he has been informed by the engineer to the railway that the Bank of England would not permit any part of their building to be interfered with, and the Company has not sought power to take the land for the purpose. The subways will be lighted by electricity. By Clause 68 of the Act of 1891 there are to be no advertisments on any part of the Company's premises in view of the public, while under Clause 69 the Company must deposit objects of geological or antiquarian interest at the Guildhall, to become the property of the Corporation.

The Telephones and Electric Traction.—The Joint Committee of the Houses of Lords and Commons appointed to inquire into the question of uniform protective clauses for telephone and other companies, in relation to Bills promoted for electric railways and tramways, met on Monday to select a Chairman and to consider the course of procedure. Lord Cross having been chosen Chairman of the Committee, Sir Theodore Martin, on behalf of the National Telephone Company, asked that they might be represented by counsel, the adoption of which course, he believed, would much abridge the length of the inquiry. Similar applications were made on behalf of the Associated Railway Companies, the Electric Traction interest, the Association of Municipal Corporations, the London County Council, and Scottish Corporations. The Committee room was then cleared, and on the re-admission of the public, Lord Cross said that the Committee had decided to meet again on Monday next at 2 o'clock, for the purpose of hearing Sir Courtenay Boyle on behalf of the Board of Trade. He, of course, would not be cross-examined by Counsel at all. The Committee would afterwards meet *de die in diem* at 11 o'clock, with the exception of Saturdays. They had decided to hear one counsel only from the following bodies:—The Railways Association, the National Telephone Company, the Electric Tramways and Railways together, the Electric Lighting Companies, and one representing all Municipalities, both English and Scottish, including the London County Council. The Committee would only hear one counsel speak on behalf of each of the five bodies named. Sir Theodore Martin applied that the Committee would take the case of the National Telephone Company immediately after the conclusion of Sir Courtenay Boyle's evidence, and the Committee acceded to this course. The Committee then adjourned.

Electric Lighting at Kensington.—At the meeting of the Kensington Vestry last week the Select Electric Lighting Company appointed by the Vestry on December 7th last, submitted the following report:—"The Committee have considered a letter received from the Notting-hill Electric Lighting Company, intimating that they are prepared to take over the area in North Kensington which the House-to-House Company proposes to abandon, and submitting a schedule of the streets which they agree should be made compulsory, but before further considering this application on the part of the Company, the Committee have deemed it desirable to request them to furnish a plan showing the streets in their present area in which they have already laid electric mains, and also to supply further information as to the actual financial position of the Company. That the Committee had before them, pursuant to the reference by the Vestry of May 24th last, the letter from Sir Frederick Leighton, Bart., P.R.A., calling attention to the fact that electric lighting mains have not been laid in Holland-park-road by the Notting-hill Electric Supply Company, and inquiring whether the Vestry can enforce the supply of electrical energy to his house (No. 2 in the road), or whether steps might be taken to rescind the Company's order, and have requested the Vestry Clerk to forward the Company a copy of the complaint referred to, accompanied with a request that the Committee may be furnished by the Company with an explanation of their default in the matter. That the Committee have further considered the reference by the Vestry of March 1st last, as to whether it would be advisable for the Vestry to apply for a Provisional Order empowering them to lay down plant for lighting the streets of the parish with electricity, and also to supply electricity to any part of the parish in which mains have not already been laid down by existing electric lighting companies, and have again had before them the report which has been prepared by the lighting engineer on the subject; and recommending that the lighting engineer be empowered to place himself in communication with a consulting electrical engineer, to be selected by your Committee, to report jointly with him upon the whole question." The report was agreed to.

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THE "HARP" ARC LAMP.

An arc lamp of remarkable simplicity has been brought out by Messrs. Chester and Rathbone. The pattern, which is illustrated in Fig. 1, is intended for simple parallel working for continuous or for alternating currents. The carbon holders slide freely on a brass tube, and are prevented from revolving round it by a lightly strained wire guide. The holders are connected by a flexible braided wire cord which passes over a rubber wheel. This wheel, as will be seen in Fig. 2, is mounted on a hanging frame, across the top of which is fixed an armature and tension lever. A club-foot electro-magnet, that is, a horse-shoe with one coil only, and having a laminated core, pulls down the armature when the current is turned on. A rubber band on the armature softens the blow. The rubber wheel swings to one side, and in consequence of the arrangement of the cords, strikes the arc. The wheel is then held firmly against a brass stop, but as the current diminishes, the pressure is relaxed until the greater weight of the upper carbon holder causes it to feed, the rubber wheel assuming the position shown by the dotted circle.

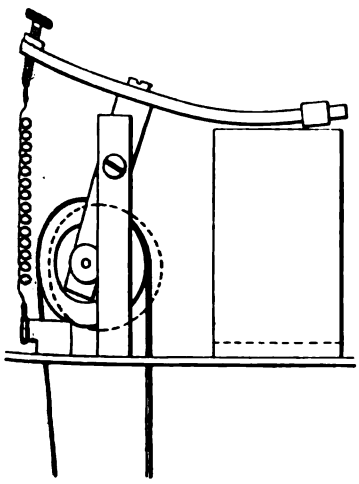


FIG. 2.

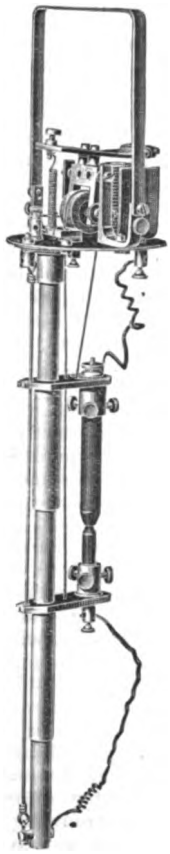


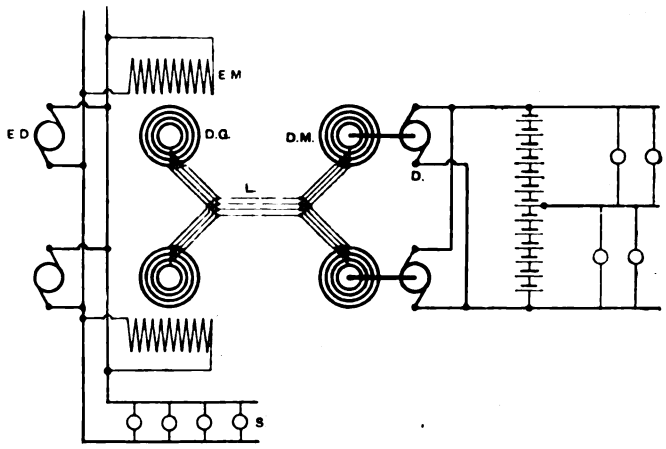
FIG. 1.—The "Harp" Lamp.

Should the lamp over-feed, the device allows a little recovery. By a slight adjustment of the control spring the lamp may be used for alternating currents. The use of a flexible wire cord has been proved by experience to be satisfactory, and avoids the necessity for absolute straightness of the carbon rod where a clutch is used, and for the wheel work which is required when racks are employed. The "Harp" lamp admits of the addition of a shunt coil in the place of the tension spring where lamps are to be run in series, and we are informed that Messrs. Chester and Rathbone have such lamps in hand. In addition to the extreme simplicity of this invention, it should be observed that the absence of a carbon rod allows this lamp to be used in situations in which there is but little head room; a very important consideration, which has often prevented the use of arc lamps in factories. We are informed that the rubber wheels show no sign of deterioration after some months' work, but even if this should occur, a metal wheel could easily be substituted for the rubber one, and a spring abutment for the fixed metal block.

ELECTRIC LIGHTING IN BUDAPEST.

The Austrian Gas Company is about to undertake the electric lighting of Budapest, and the way in which the scheme is proposed to be carried out is of some technical interest.

The electric light works are to be about two miles outside the town, and it is proposed to carry out the transmission by means of two-phase currents. The station plant will at first be laid down with a view of supplying 20,000 8 c.p. lamps, the distribution net-work being equal to a load of 32,000 lamps.



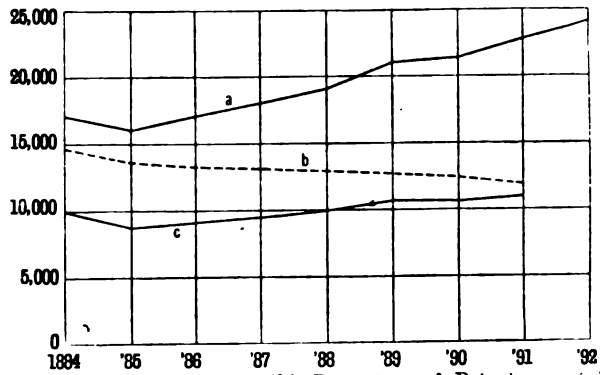
S. Lighting at Station E.D. Exciting Dynamo. E.M. Exciting Magnets. D.G. Alternate Double-Current Generator. D.M. Alternate Double-Current Motor. D. Continuous-Current Dynamo. L. Line.

The station plant is to consist of two vertical, triple-expansion 500 H.P. machines, coupled direct to 1,800 volt, 100-ampere, two-phase dynamos, which will be worked in parallel. The line will consist of two armoured lead-covered concentric cables, the fourth conductor acting as a reserve. The two-phase current will be taken to a sub-station, where it will drive motors coupled direct to dynamos, supplying current to the lamps and charging a battery of accumulators of a capacity of about 1,500 to 2,200 ampere-hours, and capable of discharging at the rate of 1,000 amperes.

This installation, which is shown diagrammatically in the annexed sketch, is to be carried out by Messrs. Schuckert and Co., of Nuremburg, who are under contract to have a portion of the installation in working order by the coming winter.

PATENTS IN 1892.

During last year 24,171 patents were applied for, as against 22,888 in 1891. It will be observed from the annexed curves



(a.) Applications for Patents. (b.) Percentage of Patents granted to number of applications. (c.) Patents granted.

that ever since 1885 there has been a steady increase in the number of patents applied for, and an equally steady decrease in the *percentage* actually granted. This, the Comptroller-General remarks in his report, "is doubtless in some measure owing to the advantage taken by inventors of the provisions of Section 4 of the Amendment Act of 1885, which prescribed that abandoned applications should at no time be open to

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public inspection or be published by the Comptroller. Consequently inventors who may be unable to proceed with their applications within the term first allowed by law, are now in a position to renew their applications from time to time, without risk of losing their rights, which would have taken place under the law as it stood before the Amendment above mentioned." However, notwithstanding the diminished *proportion* of applications which obtain patents, the total number of patents issued annually has, it will be seen, considerably increased since 1885.

The gross income of the Patent Office is now close on £200,000, of which over £180,000 accrues from patent fees. The gross expenditure last year was £96,822, of which salaries accounted for £52,835, printing for £19,000, and new buildings for £13,005; the surplus being £103,036. If we deduct the sums devoted to buildings it will be found that while the gross receipts of the Patent Office have increased some 106 per cent. since 1885, the gross expenditure has increased less than 8 per cent.

THE FAURE-SELLON-VOLCKMAR PATENTS IN THE FRENCH COURTS.*

BY CH. HAUBTMANN.

The judgment given on the 5th May by the Court of Appeal in Paris in the action brought by the Société Française des Accumulateurs, has produced a justifiable sensation in electrical circles and in the law courts. Indeed, the judgment in favour of the Société Française, declaring all who employ lead salts or oxides in the manufacture of accumulators infringers of the Faure patent, is big with consequences by reason of the judges having given their decision in the face of the contrary report of the experts and the opinion of the Ministère Public.

Looking at this fact by itself, the question immediately arises, why nominate experts to advise in an action for infringement if no notice be taken of their report in the judgment? When it is a question of infringement there are only two possible ways of looking at things, either the patents said to be infringed are valid, or they are not. Now to decide this very often exceedingly delicate question, a thorough knowledge of the question at issue is requisite, and it is especially necessary to examine with great care the invalidating instances which defendants never fail to produce. In many cases the scientific and commercial knowledge of the experts are put to a severe test, and the drawing up of a report is not always an easy matter even to experienced men. So we were a little surprised to see the Court pass over the advice of the competent men whose assistance it had invoked, and settle the matter in a purely judicial sense, letting alone the commercial and scientific aspect of the question. If this mode of procedure takes root amongst us we must anticipate disagreeable surprises for French manufacturers, for if it be granted that the advice of the experts is only of secondary importance in commercial cases, one may well ask whether the decisions given will not, as a rule, bear the impress of absurdity.

In the Faure accumulator action the experts had to answer two questions:—(i.) Examine the Faure-Sellon-Volckmar patents, and say if they are valid, and for what purpose. (ii.) Examine the alleged infringing apparatus, and point out the differences and the resemblances that exist between it and the patented apparatus, and declare whether the alleged infringements are really such.

The first question must have put the experts in a terrible hole. In fact, nothing can well be more difficult than to determine the validity or invalidity of a patent which has for its object a process of manufacture on which more or less public experiments are constantly being made. A newspaper article or an author ventilates an idea, which is never put into practice, yet it may prove an anticipation. Similarly, more or less successful laboratory experiments, if sufficiently notorious, may prove an obstacle to the validity of a patent taken out by anyone ignorant of these experiments. And, as far as accumulators are concerned, the number of articles that have been written and the number of experiments that have been made are truly incredible.

I have no intention of going over the Faure patent action again. I only desire to point out the difficult situation which will be created for manufacturers if the Courts set to work to sanction monopolies based on patents that experts and experienced men consider invalid.

So far as the use of lead salts and oxides in the manufacture of accumulators is concerned, the anticipations urged by the defendants, owners of the Philippart process, deserve to be examined with much care, and after ripe reflection one still asks oneself who is the first and true inventor of these accumulators. I, of course, thoroughly recognise the value of the work done and services rendered by Faure in this matter of electric accumulators, and it is true that the results of his labours set forth in his patent of 1881 should enjoy an assured commercial protection. But it is a long cry from that to the granting of a monopoly of all lead salts and oxides. Methods of manufacture go for something in estimating the commercial value of accumulators. Moreover, because a principle has been more or less vaguely pointed out in a patent or pamphlet, it certainly does not do to jump to the conclusion that it is the absolute property of the person who first mentioned it. If this were to be the case manufacturing would be impossible, as this would be the greatest obstacle one could oppose to its progress. To convince oneself of this, it is only necessary to run over the tests of the patents taken out during the last fifty years, and one immediately realises the formidable number of patents taken out for the most part by ignoramuses who, infatuated with an idea, patent it at any cost and never succeed in putting it into a practical shape. Sometimes the idea is a good one, and when it is hit upon later on by an experienced practical man it gives excellent results. Nine times out of ten the commercial engineer has not the time necessary to look up previous work, and is generally ignorant of previous failures. Arrived at his goal with his patent made public, patent agents trot out from goodness knows where eight, ten, or twenty patents on the same thing, which often have much resemblance, fundamentally, to the invention in question. In such instances success lies, as a rule, in details, in factory methods, and if twenty men have previously failed it is because they did not know how to set to work. From the point of view of equity the *process of manufacture* belongs rightly to him who has discovered it, and the principle enunciated, even clearly in previous patents, ought not to affect those who have found a way of putting it into practice. Of course, the law does not allow principles to be patented, but it is often an easy matter to get round the law and to patent a principle; witness this very patent of Faure's.

In Faure's patent of October 20, 1880, and in the two additions of January 10, 1881, and October 19, 1881, he claims the use of two electrodes coated with metallic salts, particularly oxide of lead. Now Poggendorff tried two electrodes consisting of platinum strip covered with platinum oxide. In 1856 de la Rive tried a secondary cell with a strip of platinum covered with lead peroxide and a plain strip of platinum. In 1854, Sinsteden made a secondary cell with two lead electrodes, and he noticed that one of these electrodes became covered with lead peroxide and the other with hydrogen. In 1861, Kirchoff made a cell consisting of two strips of perforated platinum. On one he placed lead peroxide, on the other lead crystals. He also tried two lead strips. In 1860, Planté invented his accumulators with two lead strips. He showed that lead was the best metal to use, and that it was necessary that one of the strips should be covered with lead peroxide and the other with spongy lead. Again, we find, in an article in *The Electrician* of 1863, the description of a secondary cell consisting of a strip of platinum surrounded with lead peroxide, put on mechanically, and of a sheet of zinc. In 1870, Planté tried to mechanically apply red lead (minium) and protoxide of lead (litharge) to lead electrodes. In 1879-80 Brush made the same attempts as Planté, so far as concerns the application of lead oxides to lead electrodes. There is, consequently, no room for doubt on this point. Two similar electrodes had been employed long before Faure and lead oxide had been tried in secondary cells, long before Faure's patent of 1880. The only thing original in this patent is the method of fixing and retaining the oxide on the electrodes. That idea, abandoned to-day, gave birth to the patent of Volckmar of October, 1881, in which was claimed the use of cellules in which the active material is lodged, in fact, the grid plate of the modern accumulator. I mentioned above several examples of perforated secondary cell electrodes. Finally on March 10, 1882, Sellon patented the lead antimony alloy for accumulator grids. The Sellon patent was invalidated by a decree of the United States Courts, which runs as follows:—No one may claim that a piece of apparatus made in part or in whole of a substance more suitable for the purpose which the piece of apparatus is intended for than the substance of which the original piece of apparatus is made can be distinguished from the original because it is better and, for this reason, cheaper, and that it gives on that account a right to a patent in the sense used in the patent law.

To sum up, the principle, or rather the use of lead oxides in the manufacture of secondary cells, was not, as I have shown above, employed for the first time by Faure, but it is just to recognise that with the Faure patent, the validity of which we do not wish to discuss, the Volckmar grid, and the Sellon alloy, commercial accumulators, unknown until then, were made in 1881-82.

According to my way of looking at things, the commercial value of these accumulators rests entirely on the way they are made, and that it is owing to workshop details that the manufacturers succeeded where others failed. It is, therefore, just that those who have obtained these results should be safeguarded to a certain

* From *L'Electricien*.

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extent. In these days, electric lighting developing in an extraordinary manner, accumulators became, in many central stations, a means of distribution, and every endeavour was made to improve them, both from the point of view of manufacture and of efficiency. It was then that the Faure patent became an obstacle, for its owners immediately claimed to be the only ones who could use lead salts or oxides. Is this claim valid? Evidently not, since long before Faure, lead oxide, applied mechanically to the electrodes, was used in secondary cells. The French Courts have held otherwise, and I have no qualification to criticise this decision, which converts the manufacture of accumulators into a monopoly, and renders liable to infringement suits all who are employed in the business, even if they go to work in a very different way to Faure. To day it is certain that, owing to this decision, the mere fact of using a lead salt in making an accumulator amounts to an infringement of the Faure patent. I admit I never should have thought so, and many others are in like case.

THE ALTERNATE-CURRENT MOTOR CONTROVERSY.

In our issue of May 19th we noticed an attack on Mr. Brown's motor, to which Mr. Brown replies in the *Elektrotechnische Zeitschrift* for the same date. He remarks that the "3-4 H.P." motor shown him in June, 1890, was about as big as a 10-15 H.P. motor of present design, and he considers that it requires some assurance to allude to this motor as if it only wanted little to make it a really practical machine, as it had practically no efficiency and made a terrible noise. Mr. Brown said he recommended his people to take out a licence because he thought he could correct the error of its ways, and because at that time he thought Herr Dobrowolsky was the inventor of the three-phase system; he never laid claim to the invention of the three-phase motor, but he claims to have been the first to make a practical one. Herr Dobrowolsky came to Oerlikon to see how it was done, and it was this Brown motor that decided the character of the Lauffen-Heilbronn transmission. As regards the armature, Mr. Brown considers that the Dobrowolsky patent shows an armature in which eddy currents are encourged, whereas in his own armature they are got rid of, and only induced currents in the winding are used. As regards a quotation from Mr. Swinburne, Mr. Brown says that his motors have been working for some time on circuits of a frequency of 100 and 140 ∿. He concludes by promising shortly to publish more figures for single-phase motors of different sizes, and made for a periodicity of 40-60.

To this Herr Dobrowolsky replies that since Mr. Brown has not published data as challenged, he considers himself justified in believing in the inferiority of the Brown motor; that the efficiency of the 3-4 H.P. motor was not 0, as its output could be raised to 6 H.P.; the difficulty was in starting, as the initial torque was small. The question of the armature he cannot discuss, as the Allgemeine Elektricitäts Gesellschaft has informed Mr. Brown that they consider that he infringes their patent.

Mr. Brown finally retorts that, of course, he will not publish data too soon. He regrets that Herr Dobrowolsky in 1890 did not call his attention to the fact that his motor had an ou put, and recommends any person interested to look up the old papers of Dobrowolsky and Swinburne and see how much information he finds on the subject of the design of alternate-current motors.

Our own contribution to this apparently interminable discussion is the following letter received from Herr Arnold, of the Oerlikon Works:—"In your valuable paper the so-called Brown alternate-current motor, which is a close copy of the Oerlikon alternate-current motor that was at work in 1892, was recently appreciatively noticed. I have taken the liberty of sending you by newspaper post a copy of the *Elektrotechnische Zeitschrift*, containing an article of mine, and I should be glad if you would take notice of it, observing that the Oerlikon Works claim priority for these motors."

The article referred to is to the following effect:—"Elihu Thomson and Nikola Tesla laid the foundations of the system of design of alternate current motors long ago, although practical difficulties retarded their development, and experiments with polyphase motors have only recently cleared the pound for the design of a single-phase moter, several of which are now in daily use. Elihu Thomson was the first to show that a conductor placed in an alternating field could be made to rotate if started, or if placed unsymmetrically in that field, and tended to produce a torque, an effect which is much increased by making the conductor the short circuited winding of a laminated iron armature. Such motors have no collectors or brushes, and rotate in the direction of the necessary starting impulse; and Tesla's patent, No. 401,520, February, 1889, is very important in this connection. By this method the exciting coils are divided into two parts, the self-induction of which differs, and at starting, these circuits are placed in parallel. The currents in them differing in phase, a rotating field is produced, which starts the motor. One winding is then either cut out or placed in series with the other. But Tesla's method of armature construction, and his magnetic design, precluded success. For successful motors, the magnetic resistance should be small, and deep and wide recesses in field armatures must be avoided. The best arrangement is that in which the wires are in holes or in narrow slots, as in the Wenström design, adopted by Mr. Brown. These considerations apply, not only to polyphase, but to single-phase motors, for every polyphase motor can be made into one for ordinary alternate currents. The motors of the Oerlikon factory are examples of this, both polyphase and single-phase motors being of the following construction:—The 'inducing' coils surrounding the armature are wound as Gramme ring windings, and the wires are placed in recesses in the iron. The armature has copper rods passing through holes in the plates, and either coupled at each end to copper rings, short-circuiting them, or in groups. These motors are now made up to 12 H.P., but one of 250 H.P. has been running in connection with the Hochfelden-Oerlikon transmission for several months. An idea of the dimensions may be gathered from the following figures relating to a 6-H.P. motor:—Speed, 1,200; watts taken, 5,800; efficiency, 76 per cent.; length, 2ft.; width, 2ft. 9in.; height, 2ft. 3in.; weight, 6·4 cwt. Several methods of starting are used. Tesla's has the disadvantage of taking a very large current, but in small motors it can be applied, and the starting helped by a judicious push. A neat method is to connect the Gramme winding of the field to a collector (like a direct-current armature) fixed in any convenient place and supplied with rotating brushes; if these be rotated when the current is switched on, a rotatory field is produced which starts the motor, and the brushes can then be left in any position. Another way is that used by Mr. Brown and for which the Oerlikon Company filed a provisional patent last year. A description of the Oerlikon motors follows, which work with a periodicity of 40-70 ∿, and in which the Tesla method of starting is used. They contain all the important novelties and properties as described by Mr. Brown, and were first described in the *Neue Bündner Zeitung* of December 25, 1892, and two months before the appearance of his article."

CONDENSING PLANT FOR THE BRISTOL CENTRAL STATION.

Messrs. W. H. Allen and Co., of Lambeth, who have the whole of the contract for the condensing plant for the long incubating Bristol electric-light station, are now about to fix this portion of the plant into place. The proximity of this station to the Avon renders condensing practicable—the site having been selected, in fact, with this in view—while the extreme dirtiness of the river water, and the strong chemicals dissolved in it, make it necessary to have a special form of condenser. This is the first occasion on which a large condensing plant of this kind has been adopted for central stations; and Messrs. Allen and Co. are to be congratulated on the manner in which, in the equipment of this plant, they have surmounted the many special difficulties which have been encountered.

The entire plant is sub-divided into three similar sections, consisting each of a surface condenser, an evaporator, and air and circulating pumps, with engines for driving them. Each section is capable of condensing 30,000lb. of exhaust steam per hour, and consists of a horizontal circular shell, 4ft. 1in. in diameter and 8ft. 6in. between tube plates, with internal tube plates, to which a large number of longitudinal ¾in. gun-metal tubes, of No. 18 S.W.G., with a total condensing surface of 2,422 square feet, are fastened by ferules. By means of a diaphragm at the front end of the condenser shell the tubes are divided into two sets, one for forward and one for return flow, by which the cold water is carried twice along the condenser. The circulating water occupies the spaces between the tube plates and the ends of the shell, and completely surrounding the tubes. Circulation is produced by the "Conqueror" centrifugal pumps, direct-coupled to Messrs. Allen and Co.'s vertical compound engines. The engine cylinders are 6in. and 12in. diameter, and 12in. stroke, and the pumps are capable of raising from 2,500 to 2,800 gallons of water per minute from the river, which is at a depth of 15ft. below the level of the engines. A safety governor is fitted to each of these engines, which would come into action in the event of the pump losing its water, and each pump is provided with a charging apparatus, by which it may be quickly charged. Surmounting each of the condenser shells there is a supplementary feed evaporator, by means of which, in the event of the water in the hot well failing, an additional supply of hot clean water can be given to the hot well. This evaporator is of novel construction, and consists of two cylindrical shells, arranged like the shell and flue of a Cornish boiler, with the inner shell crossed by 26 diagonal water tubes of 2in. diameter. The exhaust steam passes through the inner shell and around the cross tubes on its way to the condenser, and gives up some of its heat to a large bulk of clean water which fills the spaces between the outer

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and inner shells. The vapour which is thereby produced passes down to the condenser, and mixes with the exhaust steam. Both are then removed to the hot well by means of the air-pump. In the event of the exhaust steam not evaporating a sufficient quantity of water, the evaporator may be supplied with a circulation of live steam, which can be admitted from the boilers through a ¾in. pipe. The vapour is taken from the evaporator by means of a 3in. pipe.

The air pumps are of large capacity, and are specially designed for long and continuous working. Each pump has a capacity of 250 cubic ft. per minute, and is direct driven by one of Messrs. Allen and Co.'s compound engines. The engine cylinders are of 10in. and 16in. diameter, and the pump barrels are of 16in. diameter; the stroke is 10in., the piston rods of the engines being rigidly coupled at the crosshead to the pump rods by means of two stiff rods working in guides. The crosshead also drives a crank shaft, by means of a connecting rod; but the thrusts on the cranks are very small, as they are only required to supply motion to two fly-wheels which are keyed to the shaft. The fly-wheels are designed to give steady rotation at low speeds; and a crank shaft governor, actuating the piston expansion valves, controls the engines when the pumps fail to lift water. Special arrangements have been made for lubricating these engines from one common oil reservoir, the oil being distributed through pipes to each of the working parts, and the feed being regulated by sight.

The exhaust steam from all the engines passes directly to a cast-iron ring pipe, from which it is passed into the three condensers. The pipes are of 12in. and 15in. diameter, and have four large copper expansion joints; and the main exhaust to the condenser is 18in. in diameter. The pipes are anchored at two ends, having the sides free to expand. The whole of the exhaust can be turned into the atmosphere in the event of a breakdown of any portion of the condensing plant. The main steam ring, which is also supplied by these engineers, consists of pipes 6in. and 7in. in diameter, with connections from the boilers of 5in. in diameter. All the flanges and T-joints are electrically welded by the Bernardos process. These electrically welded pipes have, so far as we are aware, been put into no large station, except that of the Metropolitan Company at Amberley-road, Paddington; and it is, without doubt, considerably in advance of the usual practice, as the steam pipes have been successfully subjected to a pressure of 1,500lb. per sq. in.

THE ELECTROLYSIS OF WATER PIPES.*

BY C. H. MORSE.

When electric cars were first put in operation in Cambridge (Mass.) they depended upon mother earth, the water pipes, the gas pipes, and anything over which the current could flow, to convey it to the station or act as a sewer. No thought was given to the loss which would result to the Company from doing this, to say nothing about the effect upon pipes. I can, perhaps, illustrate this loss by saying that three months ago, in parts of Cambridge, the loss of pressure due to the power which was required to force this current back over this uncertain path was 20 per cent.

When the Railroad Company put in their power plant, they run large numbers of feeders and one wire between the rails, and attached the two rails to this return wire. This became very soon an uncertain path, as it was found that electrolytic action took place upon this wire and it disappeared in places. They thought at first that it was due to something in the soil, but it was very soon traced to the enemy, that is, electrolytic action. I remember the practical experience we had with these dead rails, as we call them. When this wire was eaten off and a car came on to that section, if by any chance you placed one foot upon the rail and another upon the ground near it, shocks could be obtained.

Mr. Nevons and I went to the different places where we had traced these difficulties, or where they had been called to our attention rather, and found that lead pipes had disappeared in a short space of time, some even in six or eight weeks. Iron pipes had been tried with the same result, also galvanised iron; brass pipe had been put in, and deterioration was noticed at once. Rustless iron was tried, and it did rust decidedly. It was not the work of any mysterious agent, but was the result of what almost all of you have seen in school experiments, that is, the decomposition of water. A speedy remedy for that, of course, was easily apparent, that was to reverse the current. So the officials of the West End Railroad Company were invited to a Conference with the Water Board and myself, and I am pleased to say the Company were willing and anxious to do anything in their power to obviate this difficulty. A certain amount of credit belongs to them for that, although, of course, they had themselves a reason for wanting to do it. They were losing anywhere from 5 to 20 per cent. of their power in this return.

Observations were made by several of the waterworks *employés* unintentionally. Such an immense amount of current was flowing over the pipes that upon attempting to make a joint by putting oakum around the pipe, it was found that the electric arc was sufficient to set fire to the oakum, frightening the men considerably. Tests were made in different parts of the city by means of instruments adapted for the purpose, and we found between North Cambridge, Harvard Square, Central Square, and East Cambridge a fall of potential all the way from 25 to 45 volts. Now, there should be no fall of potential, but there was a loss of from 25 to 45 volts, from 500 volts, which is the maximum pressure, making more loss than can be allowed with economy. When we attached to the negative pole of the machine and made our tests from Harvard Square, we found a loss of 100 volts, or 20 per cent. of the pressure. You can now see, as I said before, why the Company was very ready to take hold of this matter.

How are we to remedy the difficulty? I know of no way by which we can use the single trolley wire system and overcome this difficulty without putting up an immense amount of overhead returns, through which the resistance will be reduced to almost nothing. How far the Company will be willing to go in this I cannot say. Their spirit has been so admirable in the past I have no right to suppose but what they are willing to carry it to that extent. Certainly, the city will require it carried to such an extent that the pipes will be in perfect safety. The maximum amount of current which can be allowed to go over them I am unable to tell you at present, but a series of experiments are being conducted now at my house to determine this. I have some pipes buried in the earth, the current flowing over them, and I am watching carefully the deterioration daily. I am in hopes to make a report soon to the Water Board upon the maximum amount which can be allowed to flow upon iron pipes.

By doing what we did, reversing the current and attaching our water pipes to the negative pole of the dynamo, we hurt one of our old friends seriously, that is, the Gas Company. You see the effect. The current will flow on the water pipes, and it has an easy chance to leave them through their connection with the negative pole of the dynamo. Now it flows along on a gas pipe, and as soon as it can it will leave the gas pipe to take to the water pipe. I felt it my duty to make this clear to the President of the Gas Company, and called his attention to it, saying that something ought to be done to protect him, and a Conference was had between the railroad people and the Gas Company, and I was invited to be present. At that time we made an arrangement with the Company which will help it somewhat in that direction, and help us as well as them. We propose now to connect the gas pipes and the water pipes together in all parts of the city. It will be done in buildings. A man from the West End Company has been appointed who goes as a gas man to the different stores and factories, and in those places he will solder a wire to the gas pipe and also to the water pipe. This can do no injury to either, but will decidedly help both companies.

I was somewhat surprised at the way they attempted at first to return the current. There are girder rails that have, we will say, 10 sq. in., some of them have as high as 14 sq. in. sectional area. That would have a carrying capacity equal to a piece of copper 2in. square. And yet these rails are bonded by a No. 4 copper wire, a wire smaller than a lead pencil. It seems quite ridiculous that they should require this little bit of fine copper wire to carry as much current as a big rail, where they should have a piece of copper wire, as I said before, for these big rails, of at least 2 sq. in. sectional area. There is another remedy also which we hope to carry out early in the spring, and that is to abolish completely this return wire between the rails, by cutting it into sections of about 400ft., and connect each of these sections with the return wires. Most of the current will then return by these copper wires. Of course, some of it will flow over the water pipes; that cannot be helped as long as one side of the machine is connected with the earth. Another remedy which is to be adopted, is a special line of feeders attached only to the water pipes; that is, a feeder will be run from the central power house to the different parts of the city, which will not be connected with the machines at all, but will be connected with the water pipes at the central power house and with the pipes in all sections of the city. This will also materially reduce the electrolytic action.

* Abstract from a Paper read before the New England Waterworks Association.

The Telephone in Turkey.—It is said that the Sultan's fear of conspiracy has prevented the introduction of the telephone in Turkey. Not only will he not allow telephone lines to be laid in Constantinople, but he objects to them even in the other great towns, such as Smyrna and Salonica. This is so well known that for a considerable time those interested in telephone matters have ceased to apply for concessions.

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PHYSICAL SOCIETY.

At the ordinary meeting of this Society, on June 9, 1893, Prof. J. Perry, F.R.S. (Vice-President), in the chair, Mr. A. P. TROTTER read a Paper on

"A New Photometer."

The author has modified his "Illuminati Ponhotometer" (described *Proc.* I.C.E., Vol. CX., Paper No. 2,619) so as to adapt it to the measurement of candle-power. The principle employed is to view a screen, illuminated by one source, through an aperture in a second screen illuminated by the other light, the aperture becoming invisible when the illuminations are equal. After using perforations of various patterns, a series of narrow slots, cut in thin paper, were found to give the best results. The plain screen is mounted behind the slotted one in a box sliding on the photometer bench, and they are arranged so that the light falls on them at equal angles. The screens are viewed from a distance of 6ft. or 7ft. through an opening in the front of the box, cords being provided for producing the traversing motion. Two "sights" set respectively at the middle of the length of the plain screen, and on the lower edge of the front opening, serve to show when the middle of the band of equal illumination is vertically above the pointer on the carriage. The photometer is found to be particularly valuable when it is desired to determine the maximum power of a variable source. When lights of different colours are being compared, say a gas flame and an arc, one end of the screen shows blue strips on a yellow ground, and the other end yellow strips on a blue ground; at the centre the colours seem to blend. To facilitate the comparison of such lights Mr. Crompton, who has been working at the subject simultaneously with the author, uses one screen tinted pale yellow and the other pale blue. Details of construction of the photometer are given in the Paper, and the accuracy attainable when comparing the equal lights of about eight candles is stated to be about 1 per cent.

Prof. S. P. THOMPSON, F.R.S., read

"Some Notes on Photometry."

The first note relates to "The Use of Two Overlapping Screens as an Isophotal," and describes the evolution of the Thompson-Starling photometer. In this instrument a prismatic block with apex upwards rests crosswise on the photometer bench, and the inclined sides are respectively illuminated by the two sources to be compared. In testing differently coloured lights, coloured stuffs were placed over the surfaces of the edge. In some cases notched and overlapping cards were used to form the overlapping surfaces. An inclination of about 70deg. between the two surfaces was found convenient. The second note refers to the "Periodic Principle in Photometry," and in it the author discusses the various methods which have been, or may be, used for producing small differences of decreasing amount between the two sides of a photometer screen. By employing a device of this kind much greater accuracy of adjustment is possible. In one form of vibration photometer, worked out by the author, the paraffin blocks of a Jolly's photometer are mounted at one end of a spring, the other end being fixed to the carriage. The act of moving the carriage starts the blocks vibrating, thus producing the desired variations.

In a third note the question of using "The Electric Arc as a Standard of Light" is dealt with. Since 1878 the positive crater has been used as a standard of whiteness, and last year both the author and Mr. Swinburne suggested that a given area of crater might be used as a standard of light. This proposal has since been carried out by M. Blondel. Since the intrinsic brilliancy of the crater is high, it necessitates very small apertures, or else the use of standards of large candle-power. Advantages of using powerful standards are pointed out in the Paper. With a circular hole 1mm. in diameter, a standard of about 55 candles could be obtained; with such a source, benches longer than usual would be preferable. At the end of the note, the errors which may be introduced by using as an arc standard a hole in a plate of sensible thickness, when viewed obliquely, are investigated, as well as those due to inaccuracy of setting the plane of a hole made in foil, perpendicular to the photometer bench.

DISCUSSION.

Major-General FESTING, in opening the Discussion on both Papers, said reflection from the sides of the hole in a thick plate would tend to lessen the error calculated by Prof. Thompson. The ordinary impurities in carbon were not likely to alter the brilliancy of the crater. Captain Abney and himself had no reason to distrust its constancy. Both the vibrating photometer and Mr. Trotter's arrangement would be very useful.

Dr. SUMPNER said his photometric experience had been obtained with the Bunsen, Jolly, and Lummer-Brodhun types. With the two former the inaccuracy arising from uncertainty of adjustment was about ½ per cent. Changes of about 0·4 per cent. (average) resulted from reversing the screens. The Lummer-Brodhun instrument (which he described) was better than either of the other two, the average error being about ¼ per cent.

Mr. FRANK WRIGHT thought scientific men gave too little attention to the question of light standards. Photometers could be relied on much more than any standard at present in use. The Methven screen was the most practical standard yet devised, but, in his opinion, no gaseous flame could be a real standard on account of the influence of the surrounding atmosphere.

Prof. AYRTON saw difficulties in using long benches as suggested by Dr. Thompson, on account of the serious atmospheric absorption which occurs with light from arcs. Decreasing the intensity by dispersion or otherwise was preferable. In some tests on glow-lamps, now being carried out at the Central Institution, a Bernstein lamp used as a standard was mounted on a spring and vibrated.

Mr. MEDLEY showed the vibrating standard referred to by Prof. Ayrton, and gave series of numbers showing that with this device, in conjunction with the Lummer-Brodhun photometer, accuracies of about ¼ per cent. were obtainable.

Mr. SWINBURNE thought Mr. Trotter's arrangement was better than the wobbling photometer. As to the best length of bench, he was inclined to think the shorter the better, provided its dimensions were large compared with that of the standard light. He concurred with Mr. Wright in his remarks about the desirability of obtaining a better standard. Speaking of the arc as a standard, he said that only impurities less volatile than carbon would influence the brightness. An important factor was the emissivity of the carbon, which might not be constant.

Mr. BLAKESLEY thought the accuracy obtainable with Mr. Trotter's photometer had been underrated, and pointed out that by using quadrant-shaped screens, intersecting orthogonally on the axis of the photometer, instead of straight ones, the width of the neutral band could be greatly diminished.

Mr. TROTTER, referring to Dr. Thompson's Paper, said he had been engaged in collaboration with Mr. Swinburne in developing the arc standard. He had found considerable difficulty in making suitable pinholes. It was not an easy matter to accurately measure the hole when made. In photometric measurements he had found it very important to reverse his screens. Curved screens, as suggested by Mr. Blakesley, had been tried, but with little advantage. They also destroyed the approximate direct-reading property of the photometer. The subject of changing the length of a bench, and its effect on the gradient of illumination, was discussed. With short benches one had to guard against departure from the inverse-square law, due to appreciable size of the standard. Recent experiments had shown that the light given out by the 1 sq. mm. of crater surface differed considerably from 70 candles.

A Paper on

"The Magnetic Field close to the Surface of a Wire conveying an Electrical Current,"

by Prof. G. M. MINCHIN, M.A., was taken as read. In this Paper the author applies the solution he gave in March last for the conical angle subtended by a circle at any point in space, to determine the magnetic potential at a point near the surface of a ring of wire of finite cross section. The shapes of the lines of force near the surface, for several laws of current distribution across the section, have also been worked out.

BOOKS RECEIVED.

"The Dynamo." By C. C. Hawkins, M.A., and F. Wallis. A.I.E.E. (London: Whittaker and Co.) 500 pp., 8vo.

Proceedings of the Royal Society. Vol. LIII., No. 322. (London: Harrison and Sons.)

"Dynamoelektrischen Maschinen." By Dr. F. Auerbach, (Leipzig: A. Hartleben.)

Journal of the Institution of Electrical Engineers. Vol. XXII., No. 106. (London: E. and F. N. Spon.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

WEDNESDAY, June 21st.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Ordinary Meeting to be held at 25, Great George-street, Westminster. Papers to be read: (1) "Fifteen Years' Fog in the British Islands, 1876-1890," by Robert H. Scott, M.A., F.R.S.; (2) "Upper Currents of Air over the Arabian Sea," by W. L. Dallas, F.R.Met.Soc. Also an Address by Mr. E. D. Archibald, M.A., on "Australian Climate and Weather," illustrated by a number of Lantern Slides.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Ordinary Meeting.

FRIDAY, June 23rd.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1) "Exhibition of a Form of Carey-Foster Bridge," by Mr. Nalder; (2) "An Influence Machine," by Mr. Pidgeon; (3) "An Influence Machine," by Mr. Wimshurst; (4) "A New Volumenometer," by Mr. Myers.

INSTITUTION OF ELECTRICAL ENGINEERS.

9 p.m. Conversazione at the Institute of Painters in Water Colours, Piccadilly.

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Editorial, Publishing, and Printing Offices :

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.

Telephone No. 2714. Telegrams : "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed "Coutts and Co."*

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STEEL-PLATE PORTRAITS

Of Willoughby Smith; W. H. Preece, F.R.S. (President of the Institution of Electrical Engineers); Michael Faraday; Sir John Pender, G.C.M.G., M.P.; Sir William Thomson, F.R.S. (Lord Kelvin); C. H. B. Patey, C.B.; Dr. John Hopkinson, F.R.S.; Dr. Oliver J. Lodge, F.R.S.; Prof. William Crookes, F.R.S.; Prof. von Helmholtz; Prof. W. E. Ayrton; Lord Rayleigh, F.R.S.; Cyrus W. Field; Werner von Siemens; and Sir James Anderson, have been issued as Supplements to "THE ELECTRICIAN."

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ELECTRICITY SUPPLY.

The sessions of scientific societies being now closed, electrical engineers may profitably turn their attention from details, and take a glance at the general condition and prospects of the industry of electrical supply. However broadly a subject may be handled in a Paper read before an engineering meeting, the discussion which follows it is sure to tear off the vesture of generalisations, and to disclose the naked facts on which it was hung, even if the very skeleton is not laid bare by ravening critics. Fierce as is the controversy which rages between alternate-current and continuous-current partisans, they are agreed on the value and comfort of electric lighting as compared with other means of illumination, upon the usefulness and adaptability of electric motors, and the ingenuity and convenience of electrical cooking. An interesting review of the whole matter has been made by a man who, while unconnected with any system, has a much more intimate knowledge of the business of purveying light, heat, and power, to the public in their homes than the majority even of experienced electrical engineers. Mr. DENNY LANE, in his Presidential Address to the Incorporated Gas Institute, does not spare criticism, but he knows too much about electric lighting to disparage its value. If he had the chance he would put down an electric supply plant at Cork on the distribution-by-gas principle which he has long advocated, and which, if carried out by a man of his experience, might lead to most important changes both in the economics and in the management and proprietorship of supply business. In this Address, the first portion of which we print in another

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column, it must be confessed that undue prominence is given to the working of the London Electric Supply Corporation. The history of its troubles is pretty well known; nothing can be learned from its present condition; but while the possibility of a fair load remains for it, there is still a possibility that it will yet do all that has been promised for it. We must demur to some statistics, a matter about which Mr. DENNY LANE is generally very careful. Basing some calculations on figures put forward by Prof. AYRTON, he makes out that the whole electric lighting of Great Britain is equivalent to 1,100 million feet of gas in the year. In this calculation he makes an assumption unworthy of the impartiality with which he usually deals with electrical matters, but one which seems to be inseparable from gas engineers, namely, that 5 cubic feet of gas yield 16 candle-power for an hour. Of course, with a Parliamentary Argand burner and proper cooking of the temperature, and other tricks well known to gas testers, 5ft. of gas may generally be induced to give this light as a maximum, but in the present comparison two candles per cubic foot is a liberal estimate for ordinary domestic burners. Electrical engineers might as well base all such calculations upon the arc lamp, which takes only a quarter of a watt per candle.

The output of the London Electric Companies alone amounted to over 7,900,000 units during last year. This comes to 250 million lamp hours of 8 c.p., and, at two candles per cubic foot, is equivalent to 1,000 million cubic feet of gas in the year. This hardly alters the final comparison, but it is worth while to take actual figures when they are to hand. The electric supply of London is, therefore, at present about one-thirtieth of the gas supply, as given by Mr. DENNY LANE, reckoned as light for light, and is only a little over one-half of the yearly increase, which Mr. LANE puts at 1,800 millions. Gas engineers know well enough that mineral oil is a far more serious competitor than the electric lamp. In not a few cases electric lighting has been simply introduced to replace oil lamps and candles, the gas bill being unaltered, or even increased.

Another very useful survey, not of electric supply as a whole, but of the various systems which are now in use, has been made by Prof. HENRY ROBINSON. Endeavouring, as he does, to hold an impartial position, he is, of course, sure to be attacked by some alternate-current men for admitting that continuous currents are worthy of any consideration; while a much smaller number of low-pressure men will think that he draws the line too close round their system, and unduly limits the area over which they can effectively and economically supply electrical energy. Prof. ROBINSON condemns the two-wire low-pressure system no less forcibly than alternate-current distribution by transformers in each house. Both are regarded as obsolete, although the latter is used, says Prof. ROBINSON, by several companies in London, whose main object in adopting it was to obtain a hold over as large an area as possible with the minimum expenditure of capital. Of the three conditions upon which the choice of a system depends, the geographical distribution of the demand is the most easy to determine. The probable demand, both at the outset and in the future, and the nature of the demand, are very difficult to estimate. An electrical engineer of experience can, by visits to a town and careful observation, arrive at some idea of these conditions, or may be able to extract information about them from some of the inhabitants. The geographical distribution readily lends itself to calculation, and it is on such data that Continental electricians delight to work out the best position for the station by considering the centre of gravity of the lights, or some such abstraction. Prof. ROBINSON seems to have had the geographical condition chiefly in view when he worked out his examples. How far the other conditions would modify these results is difficult to say. The choice of a system for the lighting of a town is more difficult when the area to be supplied includes both shops and residential districts, especially when the latter, as is often the case, more or less surround the former. A notable change in the centre of gravity of the lights occurs between five and seven in winter, and does not seem to have attracted the attention of mathematicians who have busied themselves with theoretical networks and feeders.

Engineers who are called upon suddenly to give a rough estimate for a complete central station, either straight "out of their heads" or by calculation on the back of an envelope, should be grateful to Prof. ROBINSON for the simple formulæ proposed by him. The cost, he says, is £2,500 + £45 to £50 per kilowatt, according to circumstances. Turning to Dr. HOPKINSON'S estimate in his Presidential Address to the Junior Engineering Society last November, we find that a station to deliver 2,500 kilowatts should cost, without land, £120,000. Dr. HOPKINSON gave no idea of the length and size of mains and feeders, for which he set down £50,000. Working backwards to Prof. ROBINSON'S formula, we get £2,500 + £46·8, a remarkable confirmation of its general accuracy. The difficulty, of course, with such a formula is the extent of the mains and the cost of land. Taking St. Pancras station at 850 kilowatts output, the mains alone come to £2,500 + £36·8 per kilowatt; but Prof. ROBINSON expressly excludes distributing mains from his calculations. Individual contractors may find that Prof. ROBINSON'S figures are not in accord with their own experience; but his method of arriving at an estimate is well worth careful attention.

REVIEWS.

Téléphonie Pratique. Par L. MONTILLOT, Inspecteur des Postes et des Télégraphes. (Paris: A. Grélot.)

We have here a lengthy and comprehensive treatise on the practice and theory of telephones and telephonic engineering; and one which, although to a large extent dealing with foreign types of instruments and Continental methods of using them, will, we are sure, be welcomed in this country by those who are interested in telephone practice. The early chapters deal briefly with the theory of sound transmission, with various kinds of primary cells, and with the microphone and Bell receiver. Sufficient explanation seems scarcely to be given of the very important use which the induction coil has in the electrical transmission of sound. We have next the inevitable permutations and combinations of microphones, each of which is dignified by the name of some "inventor," and the sundry modifications of the Bell receiver, which are similarly distinguished. Chapters VI. to XIV., on telephone lines, accessory apparatus, and telephone offices or exchanges, are the most valuable in the whole book, and, indeed, they occupy the greater part of it. The value of these chapters is enhanced by a number of well executed diagrams of the various arrangements of the circuit. Following these, a brief chapter on faults and disturbances in the line and at the various stations contains some very useful information of a practical kind. After this comes a lengthy chapter on the French legislative side of telephone work, which is largely historical. The chapter contains an interesting table of telephone circuits in all the departments of France, up to the end of 1891, with particulars of the number of subscribers, &c. The work concludes with a chapter on the application of the telephones to various scientific and industrial purposes.

How to Manage the Dynamo. By S. R. BOTTONE. (London: Whittaker and Co.)

A dynamo must be a very easy thing to manage if all that is to be said on the subject can be put, without compression,

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into so small a pamphlet as the one before us. A few introductory remarks on what a dynamo is, a short chapter on the ceremony of "installating" a dynamo, followed by a second chapter on what to do if the dynamo will not work after it is installed, and a short glossary, comprise the entire work. But it is evident, from the nature of the information, that Mr. Bottone has only very little dynamos in his mind's eye, and seeks to give information to amateurs or those who may be called upon to take charge of a small electric lighting plant. The introductory remarks consist of the usual explanations of series, shunt, and other dynamos, and of the uses of the various parts of a machine. The chapter on putting down the machine and driving engine does not cover the whole ground of the subject, and a person really ignorant of the subject would probably find the information inadequate. Not a word is said about connecting up the circuit and regulating apparatus to the dynamo. The chapter on the defects inherent to dynamos is on the whole good; but the advice which is given, should the dynamo refuse to start working, is of doubtful value. The practice of tickling a dynamo into action by momentarily short circuiting the terminals with a short piece of cable, is risky, is damaging to the binding posts, and does not really get at the root of the defect in the machine. Of course, if a dynamo will not magnetise, it is very provoking, but momentarily short-circuiting the machine does not really cure the defect, and in the hands of an unskilled person there is great chance of the armature being destroyed. We have seen a piece of cable electrically welded to the terminals by such an operation as that described, making the short circuit a good permanent job. The glossary of electrical terms ought to be useful; but we would recommend Mr. Bottone to provide two distinct definitions for magnetic and for electrostatic induction, instead of lumping the two together into one.

ON LIGHT AND OTHER HIGH-FREQUENCY PHENOMENA.*

BY NIKOLA TESLA.

(Concluded from page 156.)

I noticed that small variations in the density of the air produced a considerable difference in the degree of incandescence of the

FIG. 23.—Curious Incandescence of a Wire.

wires, and I thought that, since in a tube, through which a luminous discharge is passed, the gas is generally not of uniform density; a very thin wire contained in the tube might be rendered incandescent at certain places of smaller density of the gas, while it would remain dark at the places of greater density, where the convection would be greater and the bombardment less intense. Accordingly, a tube, *t*, was prepared, as illustrated in Fig. 23, which contained through the middle a very fine platinum wire, *w*. The tube was exhausted to a moderate degree, and it was found that when it was attached to the terminal of a high-frequency coil the platinum wire *w* would, indeed, become incandescent in patches, as illustrated in Fig. 23. Later a number of these tubes with one or more wires, were prepared, each showing this result. The effect was best noted when the striated discharge occurred in the tube, but was also produced when the striæ were not visible, showing that, even then, the gas in the tube was not of uniform density. The position of the striæ was generally such, that the rarefactions corresponded to the places of incandescence or greater brightness on the wire *w*. But in a few instances it was noted that the bright spots on the wire were covered by the dense parts of the striated discharge, as indicated by *l* in Fig. 23, though the effect was barely perceptible. This was explained in a plausible way by assuming that the convection was not widely different in the dense and rarefied places, and that the bombardment was greater on the dense places of the striated discharge. It is, in fact, often observed in bulbs, that under certain conditions a thin wire is brought to higher incandescence when the air is not too highly rarefied. This is the case when the potential of the coil is not high enough for the vacuum, but the result may be attributed to many different causes. In all cases this curious phenomenon of incandescence disappears when the tube, or rather the wire, acquires throughout a uniform temperature.

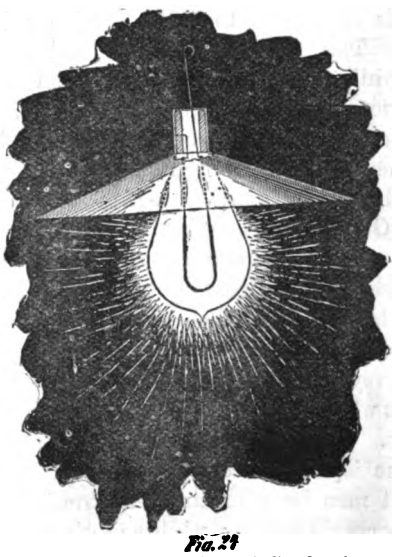

FIG. 24

Utilising the Heating Effect of Conduction Current and Bombardment.

Illustrating Lateral Diffusion.

Disregarding now the modifying effect of convection, there are then two distinct causes which determine the incandescence of a wire or filament with varying currents, that is, conduction current and bombardment. With steady currents, we have to deal only with the former of these two causes, and the heating effect is a minimum, since the resistance is least to steady flow. When the current is a varying one, the resistance is greater, and hence the heating effect is increased. Thus, if the rate of change of the current is very great, the resistance may increase to such an extent that the filament is brought to incandescence with inappreciable currents, and we are able to take a short and thick block of carbon or other material and bring it to bright incandescence with a current incomparably smaller than that required to bring to the same degree of incandescence an ordinary thin lamp filament with a steady or low-frequency current. This result is important, and illustrates how rapidly our views on these subjects are changing, and how quickly our field of knowledge is extending. In the art of incandescent lighting, to view this result in one aspect only, it has been commonly considered as an essential requirement for practical success, that the lamp filament should be thin and of high resistance. But now we know that the resistance to the steady flow of the filament does not mean anything; the filament might as well be short and thick; for if it be immersed in rarefied gas it will become incandescent by the passage of a small current. It all depends on the frequency and potential of the currents.

I have contrived an experiment which illustrates, in an interesting manner, the effect of lateral diffusion. If a very long tube

* Abstract of a lecture delivered before the Franklin Institute, at Philadelphia, February 24, 1893, and before the National Electric Light Association, at St. Louis, Mo., March 1, 1893. We are indebted to the *Electrical World*, of New York, for the blocks illustrating this lecture.

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is attached to the terminal of a high-frequency coil, the luminosity is greatest near the terminal, and falls off gradually towards the remote end. This is more marked if the tube is narrow.

A small tube about ½in. in diameter and 12in. long (Fig. 25) has one of its ends drawn out into a fine fibre *f* nearly 3ft. long. The tube is placed in a brass socket T, which can be screwed on the terminal T_1 of the induction coil. The discharge passing through the tube first illuminates the bottom of the same, which is of comparatively large section; but through the long glass fibre the discharge cannot pass. But gradually the rarefied gas inside becomes warmed and more conducting and the discharge spreads into the glass fibre. This spreading is so slow that it may take half a minute or more until the discharge has worked through up to the top of the glass fibre, then presenting the appearance of a strongly luminous thin thread. By adjusting the potential at the terminal the light may be made to travel upwards at any speed. Once, however, the glass fibre is heated the discharge breaks through its entire length instantly. The interesting point to be noted is that, the higher the frequency of the currents, or, in other words, the greater relatively the lateral dissipation, at a slower rate may the light be made to propagate through the fibre. This experiment is best performed with a highly exhausted and freshly made tube. When the tube has been used for some time the experiment often fails. It is possible that the gradual and slow impairment of the vacuum is the cause. This slow propagation of the discharge through a very narrow glass tube corresponds exactly to the propagation heat through a bar warmed at one end. The quicker the heat is carried away laterally the longer time it will take for the heat to warm the remote end. When the current of a low frequency coil is passed through the fibre from end to end, then the lateral dissipation is small and the discharge instantly breaks through almost without exception.

Incandescence of a Solid.

Phosphorescence.

Incandescence or Phosphorescence of Rarefied Gas.

Luminosity of Gas at Ordinary Pressure.

Illustrating Four Kinds of Light Effects Produced by High Frequency Currents of High Potential.

After these experiments and observations which have shown the importance of the discontinuity or atomic structure of the medium, and which will serve to explain, in a measure at least, the nature of the four kinds of light effects producible with these currents, I may now give you an illustration of these effects. For the sake of interest I may do this in a manner which to many of you might be novel. You have seen before that we may now convey the electric vibration to a body by means of a single wire or conductor of any kind. Since the human frame is conducting I may convey the vibration through my body.

First, as in some previous experiments, I connect my body with one of the terminals of a high-tension transformer, and take in my hand an exhausted bulb which contains a small carbon button mounted upon a platinum wire leading to the outside of the bulb, and the button is rendered incandescent as soon as the transformer is set to work (Fig. 26). I may place a conducting shade on the bulb, which serves to intensify the action, but is not necessary. Nor is it required that the button should be in conducting connection with the hand through a wire leading through the glass, for sufficient energy may be transmitted through the glass itself by inductive action to render the button incandescent.

Next I take a highly exhausted bulb, containing a strongly phosphorescent body, above which is mounted a small plate of aluminum on a platinum wire leading to the outside, and the currents flowing through my body excite intense phosphorescence in the bulb (Fig. 27). Next, again, I take in my hand a simple exhausted tube, and in the same manner the gas inside the tube is rendered highly incandescent or phosphorescent (Fig. 28). Finally, I may take in my hand a wire, bare or covered with thick insulation, it is quite immaterial; the electric vibration is so intense as to cover the wire with a luminous film (Fig. 29).

In the first place, I will consider the incandescence of a button or of a solid in general, and dwell upon some facts which apply equally to all these phenomena. It was pointed out before that when a thin conductor, such as a lamp filament, for instance, is connected with one of its ends to the terminal of a transformer of high tension, the filament is brought to incandescence partly by a conduction current and partly by bombardment. The shorter and thicker the filament the more important becomes the latter, and finally, reducing the filament to a mere button, all the heating must practically be attributed to the bombardment. So in the experiment before shown, the button is rendered incandescent by the rhythmical impact of freely movable small bodies in the bulb. These bodies may be the molecules of the residual gas, particles of dust or lumps torn from the electrode; whatever they are, it is certain that the heating of the button is essentially connected with the pressure of such freely movable particles, or of atomic matter in general in the bulb. The heating is the more intense the greater the number of impacts per second and the greater the energy of each impact. Yet the button would be heated also if it were connected to a source of a steady potential. In such a case electricity would be carried away from the button by the freely movable carriers or particles flying about, and the quantity of electricity thus carried away might be sufficient to bring the button to incandescence by its passage through the latter. But the bombardment could not be of great importance in such case. For this reason it would require a comparatively very great supply of energy to the button to maintain it at incandescence with a steady potential. The higher the frequency of the electric impulses the more economically can the button be maintained at incandescence. One of the chief reasons why this is so, is, I believe, that with impulses of very high frequency there is less exchange of the freely movable carriers around the electrode, and this means than in the bulb the heated matter is better confined to the neighbourhood of the button.

In regard to the incandescence of a refractory button (or filament) in an exhausted receiver, which has been one of the subjects of this investigation, the chief experiences which may serve as a guide in constructing such bulbs, may be summed up as follows: (1) The button should be as small as possible, spherical of a smooth or polished surface, and of refractory material which withstands evaporation best; (2) The support of the button should be very thin and screened by an aluminium and mica sheet, as I have described on another occasion; (3) The exhaustion of the bulb should be as high as possible; (4) The frequency of the currents should be as high as practicable; (5) The currents should be of a harmonic rise and fall without sudden interruptions; (6) The heat should be confined to the button, by inclosing the same in a small bulb or otherwise; (7) The space between the walls of the small bulb and the outer globes should be highly exhausted.

Most of the considerations which apply to the incandescence of a solid just considered may likewise be applied to phosphorescence. Indeed, in an exhausted vessel the phosphorescence is, as a rule, primarily excited by the powerful beating of the electrode stream of atoms against the phosphorescent body. Even in many cases, where there is no evidence of such a bombardment, I think that phosphorescence is excited by violent impacts of atoms, which are not necessarily thrown off from the electrode, but are acted upon from the same inductivity through the medium, or through chains of other atoms.

Coming now to the most interesting of these phenomena, the incandescence or phosphorescence of gases, at low pressures or at

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the ordinary pressure of the atmosphere, we must seek the explanation of these phenomena in the same primary causes, that is, in shocks or impacts of the atoms. Just as molecules or atoms beating upon a solid body excite phosphoresence in the same or render it incandescent, so when colliding among themselves they produce similar phenomena. But this is a very insufficient explanation, and concerns only the crude mechanism. Light is produced by vibrations which go on at a rate almost inconceivable. If we compute, from the energy contained in the form of known radiations in a definite space the force which is necessary to set up such rapid vibrations, we find, that though the density of the ether be incomparably smaller than that of any body we know, even hydrogen, the force is something surpassing comprehension. What is this force, which in mechanical measure may amount to thousands of tons per square inch? It is electrostatic force in the light of modern views. It is impossible to conceive how a body of measurable dimensions could be charged to so high a potential that the force would be sufficient to produce these vibrations. Long before any such charge could be imparted to the body it would be shattered into atoms. The sun emits light and heat, and so does an ordinary flame or incandescent filament, but in neither of these can the force be accounted for if it be assumed that it is associated with the body as a whole. Only in one way may we account for it, namely, by identifying it with the atom. An atom is so small, that if it be charged by coming in contact with an electrified body, and the charge be assumed to follow the same law as in the case of bodies of measurable dimensions, it must retain a quantity of electricity which is fully capable of accounting for these forces and tremendous rates of vibration. But the atom behaves singularly in this respect; it always takes the same "charge."

Fig. 32

Electrostatic Action Between Primary and Secondary, with Extremely High Frequencies.

We then must ask ourselves: How can free molecules or atoms be affected? It is a fact that they can be affected by electrostatic force, as is apparent in many of these experiments. By varying the electrostatic force we can agitate the atoms, and cause them to collide under evolution of heat and light. It is not demonstrated beyond doubt that we can affect them otherwise. If a luminous discharge is produced in a closed exhausted tube, do the atoms arrange themselves in obedience to any other but to electrostatic force acting in straight lines from atom to atom? Only recently I investigated the mutual action between two circuits with extreme rates of vibration. When a battery of a few jars (*cccc*, Fig. 32) is discharged through a primary P of low resistance (the connections being as illustrated in Figs. 19*a*, 19*b*, and 19*c*), and the frequency of vibration be many millions, there are great differences of potential between points on the primary not more than a few inches apart. These differences may be 10,000 volts per inch, if not more, taking the maximum value of the E.M.F. The secondary *s* is, therefore, acted upon by electrostatic induction, which is in such extreme cases of much greater importance than the electro-dynamic. To such sudden impulses the primary as well as the secondary are poor conductors, and therefore, great differences of potential may be produced by electrostatic induction between adjacent points on the secondary. Then sparks may jump between the wires and streamers become visible in the dark if the light of the discharge through the spark gap *d d* be carefully excluded. If, now we substitute a closed vacuum tube for the metallic secondary *s*, the differences of potential produced in the tube by electrostatic induction from the primary are fully sufficient to excite portions of it; but as the points of certain differences of potential on the primary are not fixed, but are generally constantly changing in position, a luminous band is produced in the tube, apparently not touching the glass, as it should, if the points of maximum and minimum differences of potential were fixed on the primary. I do not exclude the possibility of such a tube being excited only by electro-dynamic induction, for very able physicists hold this view; but, in my opinion, there is as yet no positive proof given that atoms of a gas in a closed tube may arrange themselves in chains under the action of an electromotive impulse produced by electro-dynamic induction in the tube. I have been unable so far to produce striæ in a tube, however long, and at whatever degree of exhaustion, that is, striæ at right angles to the supposed direction of the discharge or the axis of the tube, but I have distinctly observed in a large bulb, in which a wide luminous band was produced by passing a discharge of a battery through a wire surrounding the bulb, a circle of feeble luminosity between two luminous bands, one of which was more intense than the other. Furthermore, with my present experience I do not think that such a gas discharge in a closed tube can vibrate, that is, vibrate as a whole. I am convinced that no discharge through a gas can vibrate. The atoms of a gas behave very curiously in respect to sudden electric impulses. The gas does not seem to possess any appreciable inertia to such impulses, for it is a fact that the higher the frequency of the impulses, with the greater freedom does the discharge pass through the gas. If the gas possesses no inertia, then it cannot vibrate, for some inertia is necessary for the free vibration. I conclude from this that if a lightning discharge occurs between two clouds, there can be no oscillation, such as would be expected, considering the capacity of the clouds. But if the lightning discharge strike the earth, there is always vibration—in the earth, but not in the cloud. In a gas discharge each atom vibrates at its own rate; but there is no vibration of the conducting gaseous mass as a whole. This is an important consideration in the great problem of producing light economically, for it teaches us that to reach this result we must use impulses of very high frequency, and necessarily also of high potential.

Much would remain to be said about the luminous effects produced in gases at low or ordinary pressures. With the present experiences before us, we cannot say that the essential nature of these charming phenomena is sufficiently known. But investigations in this direction are being pushed with exceptional ardour. Every line of scientific pursuit has its fascinations, but electrical investigation appears to possess a peculiar attraction, for there is no experiment or observation of any kind in the domain of this wonderful science which would not forcibly appeal to us. Yet to me it seems that, of all the many marvellous things we observe, a vacuum tube, excited by an electric impulse from a distant source, bursting forth out of the darkness and illuminating the roam with its beautiful light, is as lovely a phenomenon as can greet our eyes. Viewed from a distance the effect is weak, and much of its beauty is lost, but being near, or holding the tube in one hand, one cannot resist its charm.

In presenting these insignificant results I have not attempted to arrange and co-ordinate them as would be proper in a strictly scientific investigation, in which every succeeding result should be a logical sequence of the preceding, so that it might be guessed in advance by the careful reader or attentive listener. I have preferred to concentrate my energies chiefly upon advancing novel facts or ideas which might serve as suggestions to others, and this may serve as an excuse for the lack of harmony. The explanations of the phenomena have been given in good faith, and in the spirit of a student prepared to find that they admit of better interpretation. There can be no great harm in a student taking an erroneous view; but when great minds err, the world must dearly pay for their mistakes.

COMPARISONS BETWEEN THE DIFFERENT SYSTEMS OF DISTRIBUTING ELECTRICITY.

BY PROF. H. ROBINSON.

In advising various authorities as to the most suitable system for an installation of electric lighting in their districts, I have found it impossible to give, in a report of moderate length, the reasons which lead to the conclusions and opinions contained therein. I have therefore thought it would be useful to authorities whom I am advising, if I set forth in a separate statement the data which govern the consideration of the subject. In comparing the different systems of electric lighting, it is indispensably necessary that the data should be based on conditions which are those that are likely to arise in practice, and on estimates worked out on equally liberal scales of prices.

The choice of a system depends upon the following conditions:—

(*a*) The probable demand, both at the outset and in the future.

(*b*) The geographical distribution of the demand.

(*c*) The nature of the demand, and the length of time during which the current is likely to be required.

The systems may be divided into two classes:—

I. The "Continuous Current."

II. The "Alternating Current."

The term "Continuous Current" is applied to a current which is passed continuously in one direction through the lamps, while with the "Alternating Current" the direction of the current is reversed generally about one hundred times per second. Both systems produce the same amount of light from a given amount of

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energy actually expended in the lamps. The difference between the systems lies in the manner of conveying the energy from the central station to the lamps.

The ordinary incandescent electric lamp can only be worked at pressures not exceeding 110 volts, and it is not economical to convey current long distances at such a low pressure As a general proposition it may be stated that the higher the pressure the more economically can the electrical energy be conveyed from one point to another. One way of increasing the working pressure is to place two lamps in "series" and then to distribute the current at 220 volts pressure instead of 110. This is the principle of what is called "The Three-wire System," and it can be applied to both continuous and alternating-current distribution. The same principle may be extended by placing three or four lamps in "series" and raising the pressure to 330 or 440 volts, this latter being called the "Five-wire System."

Another way of increasing the pressure to economise in the distribution, is to generate the current at very high pressures, and to transmit it at this high pressure from the central station to some point near the lamps, and there to "transform" it down to the low pressure suitable for working the lamps With the continuous current the "transformation" can be effected by employing a high-tension current to work a motor, which drives a dynamo to generate another current at the required low pressure. These transformers can be made to give out, at low pressure, from 81 to 85 per cent. of the energy that is supplied to them at high pressure when working at full load, but at lighter loads the efficiency is much less.

Alternating currents can be transformed from one pressure to another by a "Transformer" or "Converter," which consists of two coils of wire wound through a core of iron plates or strips. The high-tension current passes through one coil, and the reversals of direction in the current induce certain magnetic changes in the iron core, which, in turn, induce another alternating current in the second coil of wire, the relative pressures of the two currents depending upon the proportions of the two coils of wire. These transformers are much more efficient and much cheaper than continuous-current transformers. Small transformers, sufficient to work lamps in one private house, can be made to give an efficiency of about 93 per cent. at full load; and large transformers, sufficient to serve 25 houses or more, can be made to give an efficiency of about 97½ per cent. at full load.

The current in the primary coil varies as lamps are connected to the secondary coil, but if all the lamps are switched off there is still a certain loss going on so long as the transformer is connected to the primary mains. The perpetual waste of power amounts to 3½ or 4 per cent. of the full load in small house tranformers, but with very large sizes the waste can be reduced to about 1 per cent. of the full load

The continuous-current and the alternating-current systems may be divided under the following heads:—

CONTINUOUS CURRENT.

A. Two-wire system. Direct supply at 110 volts or less.
B. Three-wire system. Direct supply at about 220 volts.
C. Five-wire system. Direct supply at about 440 volts.
D. Continuous-current Transformer System. Current generated at about 1,000 volts, and transformed at sub-stations to feed into low-tension distributing mains.

Note.—Storage batteries may be used in combination with any of the foregoing.

ALTERNATING CURRENT.

A. The House Transformer System. Current generated at from 1,000 to 2,500 volts, and transformed down to 50 or 100 volts by small transformers placed on each consumer's premises.

B. The Sub-station Transformer System. Current generated at 1,000 to 2,500 volts, and transformed at sub-stations by large transformers feeding into low-tension distributing mains.

Note.—As storage batteries cannot be charged with alternating currents, the machinery must be kept running continuously, whether there is a profitable demand to meet or not. The alternating current is not so satisfactory for motive power as the continuous current.

The "Distributing Mains" are those to which the house connections are made, and the "Feeders" are conductors carrying current from the generating station to distant points on the distributing mains without having any current drawn off *en route*. The pressure in the distributing mains has to be kept constant within a small percentage, and it is found more economical to work the feeders with a larger percentage of variation, the pressure being regulated according to the amount of current passing, so as to maintain the required standard pressure at the distant points where the distributing mains are fed.

Where high-tension currents are used and transformed at sub-stations, the high-tension conductors may be regarded as "Feeders."

CONTINUOUS-CURRENT SYSTEM A.

The continuous-current system A (namely, the two-wire direct supply) is suitable only for private installations and for very small districts. Practically speaking, it may be left out of consideration in dealing with the distribution of electricity over districts or towns.

CONTINUOUS-CURRENT SYSTEM B.

The continuous-current system B (namely, the three-wire direct supply at about 220 volts) is the most usual method of employing continuous current. It is very economical and easy to work where the *average** length of feeders is less than three-quarters of a mile.

CONTINUOUS-CURRENT SYSTEM C.

The continuous-current system C may be used with advantage where there is a large demand at an average distance not exceeding one mile from the central station. It is a little more complicated than the three-wire system, and requires special arrangements for regulating the pressure which are somewhat costly in comparison to those of the three-wire system, unless the demand is very large, in which case the cost becomes insignificant.

CONTINUOUS-CURRENT SYSTEM D.

The continuous-current system D cannot compete with others by itself, but it is very useful in combination with the three-wire system to serve outlying portions of a district where the demand is small.

ALTERNATING-CURRENT SYSTEM A.

The alternating-current system A may be used with advantage only where the demand is distributed over a very straggling district, and where the lights are required for long periods of time. The perpetual waste going on in small transformers is a very serious drawback to this system in any place where coal is expensive. In the case of a demand arising chiefly in shops, the all-year-round efficiency of distribution is only about 66 per cent., so that the central station plant has to generate about 50 per cent. more energy than the lamps actually require. In a residential district the all-year-round-efficiency is even less. It may be taken that at the present time private consumers use their lamps only for from 100 to 400 hours per annum, and the probability is that the general average will tend towards the lower figure as people learn to economise by switching off lights when they are not actually required. This tendency is fatal to economy in supply by the house-transformer system in residential districts. Taking the demand as equivalent to 400 hours run per annum at full load (which demand is spread over about 2,000 hours in varying proportions), the all-year-round efficiency works out at only 54 per cent., consequently for every 1,000 units delivered to the lamps, 1,850 units have to be generated by the central station plant. Again, taking a demand equivalent to 100 hours' run per annum at full load, the all-year-round efficiency comes out at only 23 per cent., so that the central station plant would have to generate more than four times as much energy as the lamps require. The only argument in favour of the adoption of this system is in the smaller capital outlay involved owing to the absence of costly low-tension distributing mains, and, consequently, in the facility with which a small demand that is scattered over a straggling district can be met with a moderate capital outlay. This system, however, cannot possibly compete with other systems in the long run, and for populous districts it may be practically regarded as being quite obsolete, although it is used by several companies in London, whose main object in adopting it was to obtain a hold over as large an area as possible with the minimum expenditure of capital.

ALTERNATING-CURRENT SYSTEM B.

The alternating-current system B is a very great improvement on the first, the superiority being entirely due to the use of large transformers in place of small ones, and in supplying a large number of consumers from one transformer, which need not be capable of serving simultaneously the total number of lamps installed, whereas a transformer in a house must be capable of serving the whole of the lights simultaneously, although it may only be required to do so once or twice a year. The aggregate demand in a district never exceeds 75 per cent. of the lamps installed, and in some districts (particularly residential districts) only one-half or a third of the lamps are ever used simultaneously; the result is that, whereas there is a perpetual waste in the house transformer system representing 3½ or 4 per cent. of the power required to run all the lamps simultaneously, there is in the sub-station transformer system a perpetual waste of only about 1 per cent. of the power required to run from one-third to three-fourths of the lamps simultaneously.

The low-tension distributing mains may be laid on the three-wire system. They cost about the same as similar mains for continuous

* The term "average length of feeders" is used to mean the average distance travelled by the current before being delivered into the distributing mains. The maximum length of feeder may be double the average, or even more, and the most distant lamps may be 300 or 400 yards beyond the end of the longest feeder. This point is frequently lost sight of in comparing high and low-tension systems, and erroneous conclusions are arrived at, owing to calculations based on the *maximum* length of feeder being taken in place of the *average* as defined above.

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current, or slightly more, owing to the necessity for surrounding the conductors with an iron case to prevent the alternating current affecting any neighbouring telephone or telegraph wires. For the purposes of a general comparison between the best alternating-current system and the best continuous-current system, it may be assumed that both of them require a network of low-tension distributing mains, which will be approximately equal in cost.

In some instances it may be desirable to combine the house transformer system with the sub-station transformer system, using the former to serve small demands in outlying parts of a district in which the bulk of the supply is served by the latter system.

In cases where the average length of feeders exceeds one mile, the alternating transformer sub-station system is undoubtedly the most economical for electric lighting purposes; but the question arises as to whether it is economical in any instance to serve a district with a central station so far away from the demand. This resolves itself into the consideration of the question as to whether it is economical to serve a large district entirely from one station, or from two or more smaller stations. It is very frequently asserted that the cost of running one station is much less than the cost of running two or more of the same aggregate power, and also that by using high-tension currents the station may be placed in some very favourable position for obtaining coal, water, &c., which may be far removed from the centre of the district to be served. These advantages have been, and still are, greatly exaggerated, and entirely fallacious views are put forward about them. In some instances the site for a station has been chosen with a view to save from 10 to 20 per cent. in the price of coal delivered, when eventually the cost of coal consumed turns out to be greater, owing to the greater losses in distribution. Interest on the extra capital, and depreciation, &c., on the main feeders, will often exceed the anticipated saving due to cheaper coal.

With a view to give a clear idea as to the best system to use in particular cases, some examples will be given.

The capacity of the station is stated in kilowatts. One kilowatt is capable of delivering one Board of Trade unit per hour to the lamps. Thus a 300 kilowatt station means one which can deliver 300 units per hour to the lamps.

One Board of Trade unit is sufficient to work a 16 c.p. lamp for 17 or 18 hours, consequently the number of lamps which a station can serve simultaneously may be found by multiplying the kilowatts by 17 or 18. Thus a 300 kilowatt station will serve 5,100 to 5,400 lamps of 16 c.p. simultaneously; this may represent from 6,800 to 10,000 or more lamps, fixed according to the character of the district.

Example No. 1.

Average length of feeders, less than ¾ mile.
Service required, 1,000 kilowatts or less.

The most economical system in total annual cost (*i.e.*, including interest on capital, working expenses, maintenance, and depreciation) is the continuous-current three-wire system, with a small reserve of storage batteries to maintain the supply during periods of light load.

The alternating system can be carried out at a slightly less capital cost if the average length of the feeders exceeds 600 yards; but the working expenses are so much greater that the total annual cost exceeds that of a continuous-current system.

Example No. 2.

Average length of feeders, less than ¾ mile.
Service required, 1,000 to 2,000 kilowatts.

The most economical system will be the three-wire or five-wire continuous-current systems, with or without a reserve of storage batteries for the light load.

Example No. 3.

Average length of feeders, from ¾ to 1 mile.
Service required, 2,000 kilowatts or more.

The most economical system will be the five-wire system. The alternating transformer system comes second, and the three-wire continuous-current third, in order of economy in total annual cost. The alternating system would cost slightly less than the five-wire system in capital outlay, but this is more than counterbalanced by the heavier working expenses of the alternating system.

Example No. 4.

Average length of feeders, more than 1 mile.
Service required, 200 kilowatts or more.

The most economical system, both in capital cost and in total annual cost, will be the alternating transformer system.

Note.—If the demand exceeds 1,500 kilowatts, it would be cheaper to serve this district with two or more stations instead of one, as shewn in Example No. 6.

Example No. 5 (A *and* B).

A district about 2½ miles long, requiring a service of 300 kilowatts.

5 A. If at least two-thirds of the demand can be served direct from the central station with feeders *averaging* not more than half a mile in length, the most economical system would be the continuous-current three-wire system, combined with continuous current transformer sub-stations to serve the small demand at a distance of more than one mile, and with a reserve of storage batteries to serve the light load work. In special cases it might be better to use the three-wire direct supply throughout, with the batteries placed in sub-stations at the ends of the longest feeder.

5 B. If only one-third of the demand can be reached by feeders averaging half a mile in length, the alternating-current system would be the best, as the saving in interest on capital, &c., will be sufficient to overbalance the cost of running the machinery continuously.

Example No. 6.

A district about three miles long requires a service of 1,250 kilowatts at the outset, increasing to 2,500 kilowatts in a few years and afterwards to 5,000 kilowatts.

Leaving out of consideration the low-tension distributing mains, which would be required for both continuous and alternating systems, the following comparison is based upon the cost of central stations, feeders, and sub-stations, as regards capital and interest on that capital, depreciation of the works, cost of energy wasted in distribution, and additional cost of wages involved by working mere than one station.

The cost of central stations is taken to be £2,500+£45 per kilowatt for the alternating-current system. For the continuous-current system it is taken at £2,500+£50 per kilowatt with feeders averaging half a mile long, and £2,500+£46 per kilowatt with feeders averaging one quarter of a mile long. The difference is due to the inferior efficiency of the continuous-current system at full load when the feeder exceeds one quarter of a mile in length. In both cases, however, the extra capital required to erect two stations in place of one is about £2,500. The cost of continuous-current feeders half a mile long is about £14 per kilowatt, and the cost of high-tension alternating current feeders half a mile long is about £8 per kilowatt, and the sub-stations with alternating transformers cost about £6 per kilowatt. Interest on capital is taken at 5 per cent., depreciation at 6 per cent. on central stations, 2½ per cent. on feeders, and 15 per cent. on alternating transformers. The extra wages and miscellaneous expenses involved by working two stations instead of one are taken at £750 per annum. The output is calculated on a "load factor" of 10 per cent., which is equivalent to a run of 880 hours per annum at full load. The all-year-round efficiency of distribution is taken at 88 per cent. for the alternating-current system, and 95 per cent. for the continuous-current system, with feeders averaging half-a-mile long. The cost of the energy wasted in distribution is taken at 2d. per Board of Trade unit. It is assumed that the average length of the feeders will be one mile, if the district is served from one station; half-a-mile if it is served from two stations; and one-third of a mile if it is served from three stations.

The following table gives the capital outlay in respect of central stations, sub-stations, and feeders, and the total annual cost of all the above-mentioned items which affect the comparison:—

	Capital outlay. £	Annual cost. £
1,250 kilowatt service:—		
*One alternating-current station	86,250	10,760
Two alternating-current stations	78,750	11,040
†Two continuous-current stations	85,000	9,990
Three continuous-current stations	81,900	10,470
2,500 kilowatt service:—		
One alternating-current station	170,000	21,250
*Two alternating-current stations	152,500	20,775
Two continuous-current stations	165,000	18,675
†Three continuous-current stations	156,300	18,520
5,000 kilowatt service:—		
One alternating-current station	337,500	42,175
*Two alternating-current stations	300,000	40,250
*Three alternating-current stations	289,200	40,280
Two continuous-current stations	325,000	36,050
†Three continuous-current stations	305,100	34,730

* The best arrangements with alternating current.
† The best arrangements with continuous current.

An examination of the above table will show that the 1,250 kilowatt service can be carried on more economically, both as regards capital outlay and annual cost, by two continuous-current stations than by one alternating-current station.

The 2,500 kilowatt service can be carried on by two alternating-current stations more economically than by one alternating-current station, and still more economically by two or three continuous-current stations.

The 5,000 kilowatt service can be carried on by two or three alternating-current stations better than by one alternating-current station; but the work could be very much more economically performed by three continuous-current stations.

In every case, therefore, it is clear that a district of this magnitude can be supplied by two or three continuous-current stations

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more economically than by any alternating-current system. Moreover, the capital outlay for the best arrangement with the alternating system differs very slightly from that of the best continuous-current arrangement, and where the alternating-current capital comes out the smaller of the two, the saving in annual cost by the continuous-current system will entirely cover the difference in less than three years. In this comparison the continuous current has been calculated on the three-wire system throughout. The 5,000 kilowatt service could, however, be more economically worked by the five-wire system, which can be introduced and grafted on to what was previously the three-wire system without the slightest difficulty. The capital cost with that arrangement would then be considerably less than with the alternating-current system, and the annual saving would be more than £6,000.

The output has been assumed to be the same for the two systems, but there is very little doubt that an installation for electric lighting on the continuous-current system has a much better future for motive-power purposes than one that is on the alternating-current system. At the present time the question of motive power is coming to the front, and will be a very important branch of the business of electric supply undertakings when the works reach a sufficiently large size to enable the price of the current to be reduced below 6d. per unit as a maximum price, and to permit the introduction of a sliding scale of charges which would work out to less than 3d. per unit for consumers who require current all day long. The continuous-current system has a large field for remunerative business in this direction, as there is great competition in the manufacture of thoroughly satisfactory electric motors, whereas the same cannot be said of alternating-current motors.

Another very strong reason for preferring continuous current is that it can be used for charging storage batteries, and they open another field for augmenting the "load factor" on the central station which is not open to alternating-current systems.

Batteries in Sub-stations, to assist during Periods of Maximum Demand.

A continuous-current station, with feeders averaging half-a-mile in length, costs from £65 to £70 per kilowatt for central-station plant and feeders on the average, but the longest distance service (¾ mile to 1 mile from the station) costs from £85 to £100 per kilowatt. In such cases it becomes a question whether batteries cannot be profitably used in sub-stations to augment the capacity of the long-distance service plant and feeders.

Battery sub-stations can be erected and fitted with all the necessary appliances for charging and discharging at a cost of £100 per kilowatt, taking the period of discharge as 10 hours. The same batteries can be discharged at double the rate for four hours, so on this basis the cost is only £50 per kilowatt. It is not probable that the maximum load would ever remain on the station for more than six hours continuously. For the purposes of the following comparison, it is assumed that the cost of battery stations would be £70 per kilowatt.

The loss of energy in the batteries may be taken at about one-third, but the energy put into them would all be generated at times when the station is not fully loaded, and would involve very little, if any, additional labour at the central station. The saving in labour per unit generated would more than cover the losses in the batteries.

The following comparison depends only on the relative amounts to cover interest on capital, maintenance, and depreciation.

Additional central-station plant and feeders, costing £100 per kilowatt, involves an annual cost of £9·6 per kilowatt per annum.

A battery sub-station costing £70 per kilowatt involves an annual cost of £11·3 per kilowatt per annum, including the high rate of 15 per cent. for depreciation on the storage cells.

These figures show that although the batteries save 30 per cent. in capital, the heavy cost of maintenance overbalances that advantage.

In a few years' time, however, the comparison will be different, as improvements are being made which tend to make batteries cheaper and more durable. It is practically certain that the cost will be reduced below £60 per kilowatt, and the maintenance below 10 per cent., thus reducing the annual cost to less than £7·8 per kilowatt, or considerably less than the cost with additional central-station plant and feeders.

The corresponding figure in the case of the alternating-current system, with feeders about one mile long, would be about £9 per kilowatt per annum.

The saving in labour per unit produced at the central station, due to working the machinery at a good load during the day to charge batteries, tells largely in favour of using battery sub-stations. In the case of residential districts, where the producing capacity of a station may be trebled by the addition of battery sub-stations, the £7·8 per kilowatt will be much reduced.

Some battery makers already contend that the cost of maintenance is less than 10 per cent., but even if this is conceded, it still remains better policy to defer for a few years spending large sums on batteries, to increase the capacity of works, in order to take advantage of improvements which are sure to be made. There is no prospect of corresponding improvements in central-station generating plant.

Central-station plant lies idle for very long periods of time. The output during the year under ordinary conditions at the present time only amounts to about one-tenth of what it might be if the machinery ran continuously at full load, and even in foggy days in winter in business districts the output never reaches the equivalent of 12 hours' run at full load. In residential districts the maximum output in any one day probably never reaches the equivalent of 8 hours' run at full load. It follows, therefore, that central-station plant could be made to generate two or three times as much electricity if storage batteries were provided at sub-stations. This affords a convenient mode of doubling or trebling the capacity of continuous-current stations in the future without incurring any expenditure at the outset to facilitate extensions later on. The battery stations can be erected in any positions where the demand requires fresh provision to be made, and can be connected to the distributing mains from which the storage cells would be charged during periods of light load.

Rate of Interest on Capital.

In the comparisons given, the rate of interest upon capital has been taken at 5 per cent. in every case. If other rates were taken the results would be slightly different.

Most Local Authorities can borrow money at 3½ per cent., and at this low rate of interest the difference in comparative annual cost tells slightly in favour of the system which involves the largest capital outlay. In the case of a company seeking 10 per cent. dividends, the comparative annual costs must be modified slightly in favour of the system which requires the smallest capital outlay.

The cost of working an installation by a Local Authority is often compared with that under a company, without bearing in mind that the authority is paying off its capital while the company is not. A Local Authority can pay off its capital in 25 years with 3½ per cent. interest, in annual instalments amounting to only 6·06 per cent. on the capital, or in 42 years in instalments of 4·6 per cent. on the capital.

MR. DENNY LANE ON ELECTRIC LIGHTING.

At the Thirtieth Annual Meeting of the Incorporated Gas Institute, at Belfast, on Tuesday, Mr. Denny Lane, M.A. (the President), after some preliminary remarks, said :—

Within the now waning century, three great developments have taken place—all, from their magnitude, necessarily co-operative—gas, railroads, electricity. I am not old enough to have stood by the cradle of the first; but I have travelled on the first passenger railways in England, France, and Belgium, when I believe no others were open in the world. I saw the telegraph at work when it was open only from Paddington to Slough. I saw the earliest glow lamps, and heard some of the earliest telephones. "Once upon a time there was a king, and he had three sons," so begin scores of fairy tales; and gas, the iron-way, and electricity are the three "princes of the blood" whom the nineteenth century has engendered. I need not tell you that the eldest was and is, according to the story-tellers, the worst of characters; the second middling; and the youngest a paragon of all the virtues. Passing over the second prince, whose mediocrity condemns him to oblivion, let us study a little the characters of the vicious heir, gas, and the virtuous *frère cadet* of this royal house, entitled electric light. If the views I present seem too elementary to some of you, I have only to say that I do not seek to teach those who know everything already, but rather to give a general view of the subject to such of you as have not had time to see both sides of the shield.

It may be thought that I cherish some prejudice against electric lighting. On the contrary, I have a most friendly feeling towards that mode of illumination; for since its advent the manufacture in which we are most interested has progressed more rapidly than at any former period. The Company with which I am connected have more than once proposed to the Local Authority to take powers to supply the electric light; but the Corporation has dissented. When properly managed, I believe the light is beautiful and convenient for those who can afford to pay for it; but no better evidence of its costliness can be found than that the West End clubs of London—the richest and most luxurious institutions in the world—signed not long since a "round robin," complaining of its high price. So far as we are concerned, the new light, instead of being a star of ill-omen, has been the harbinger of success.

The figures I employ have been taken from those given by the electricians themselves. I wish that they would reciprocate this fairness, and, adopting our statements, imitate the "sweet reasonableness" which we proffer to them, and avoid the utterly unfounded statements about gas and its evil behaviour, especially its

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deleterious effects upon health. I may give one case from my own experience. About fifty years ago a professional friend of mine had gas introduced into every room of his house. Ten children were born there—the population running somtimes up to sixteen persons. But no death took place except one—that of a lady no longer young; and it was never alleged that she was poisoned by gas. The disciples of Malthus should therefore wreck all the gas-works they could reach, if this were generally the case.

The mis-statements of some of the advocates of the new light are ludicrous. Several of them assume that we manufacture nothing but gas, and "remember to forget" that the raw material yields—in coke, tar, and ammonia—products which often pay 75 and sometimes 100 per cent. of the prime cost of the coal. Again, they measure the light given by defective burners; but they allow no credit for good ones. If gas be burned in a Bunsen burner, I can show that London gas does not reach a 1-candle standard; and most bad burners are modified Bunsens, in which air is unduly mixed with gas. Again, they assume that an incandescent lamp retains its original power; while it has been proved that a 16-candle lamp declines to 8 candles, and averages only 12 candles. The Board of Trade was over liberal to the new agent, when it allowed 10 units to be the equivalent of 1,000 cubic feet of gas. Practical men say 12 or 13 units would be more correct; and yet these one-sided advocates put down only 6 units as the equivalent.

In a recent Paper, on the "Economy of Electric Lighting," that eminent electrician, Mr. Gisbert Kapp, has pointed out that, when glow-lamps are used at the power marked by the makers it takes $4\frac{1}{2}$ watts to give 1 candle. Indeed, the electricians themselves calculate that the 8-candle lamp requires 35 watts when new, or $4\frac{3}{8}$ watts per nominal candle—a quantity largely increased as the lamps grow older. Now London gas gives per 1,000 cubic feet 3,300 candles, which, multiplied by $4\frac{1}{3}$ watts, gives 14,300 watts, or over 14 units, without counting cost of lamp renewals, or the serious falling off in light-giving power. Allowing a small sum for the latter item, we may say 15 units are the equivalent of 1,000 cubic feet of gas; and at 8d. 15 units cost 10s., as against 2s. 9d. or 3s. When cannel gas is supplied, the contrast would be still more striking—over 20 units to 1,000 cubic feet. Mr. Kapp proposes to overwork the glow-lamps, giving them a shorter life; believing that the extra cost of renewals will be more than compensated by the saving in current. These wilfully blind advocates shut their eyes to the fact that a gas burner may be checked in consumption, while the new lamp must be left full on or quite off—"Hobson's choice; this or none" From counting 16-candle they have come down to 8-candle lamps; and in other small ways they have endeavourced to "whittle down" the comparative cost of the current. These statements often come from men whose names were never heard of in connection with electricity; and the authors of them might be pardoned on the theological ground of "invincible ignorance."

But, amongst them all, the boldest in reckless assertion is one who cannot plead such an excuse—Mr. Preece, the Electrician to the Post Office—a public official receiving a public salary as head of the Telegraphic Department. He has become the adviser of corporations and private companies, and the competitor of independent engineers who are not paid from the public purse. I will give you one example of his dignified style, taken from his inaugural address delivered to the Institution of Electrical Engineers last January. He says:—"If a full load could be maintained during the whole 24 hours, electrical energy could be manufactured for one-third of a penny per supply unit, which is equivalent to gas at 2d. per 1,000 cubic feet. The potentiality of economy in electric lighting is thus beyond the dreams of the *gasmen*. The most marked features in the development of this great industry are the ostrich-like blindness of the gas manager, who buries his foresight in his fat dividend, and the childish wailings of the gas technical journalists. The gas industry should itself have nursed the herculean infant who is rapidly strangling its main sources of profit." As one-third of a penny per unit is under a farthing per horse-power, I can promise Mr. Preece to maintain his full load during the 24 hours when he is prepared to supply power at that rate.

"Save me from the evil spirit," exclaimed Paul Louis Courier, "and from *metaphors*!" Here, in a small segment of a short paragraph, you appear, gentlemen, as "dreamers," as "ostriches," as "puling babies," and as the "snakes" that the infant Hercules strangled in his cradle. But not only are these threadbare metaphors mixed one with t'other, but you are combined with the most ungracious language. You can determine how far it is consistent with the dignity of a gentleman, the culture of a scholar, or the *esprit de corps* of an engineer, to employ towards those whom he should regard as members of a kindred profession, terms which, if meant for wit, are devoid of humour, and, if intended as contemptuous, recoil on him who fell low enough to use them. The dignified periods of Samuel Johnson are combined with vulgarity; and if hereafter his dignified and potent shade will meet that of the Mercury of the English Post Office in Elysium, it will no longer be Elysium for the latter.

Mr. Preece proceeds to say that the "electric light is essentially the poor man's lamp," although I have already told you that in the district most densely-packed with palatial hotels and luxurious clubs, which use the light for the longest hours, this poor man's lamp has been found too expensive for the very capital of club-land.

I will, with your permission, give some specimens of "the potentiality of wealth beyond the dreams of avarice," which Mr. Preece promises to those who embark with him on his voyage to El Dorado.

I will merely mention, in passing, the London Electric Supply Corporation; but it would be unjust to reasonable electricians to compare their schemes with that of Mr. Ferranti. By Mr. Field's tables the income of the three London Gas Companies is £4,724,000, while the capital is only £15,144,000, or three and a-half times their annual revenue. The gas capital employed by eight large cities supplied by corporations is £8,015,000, or a little over four times their income of £1,978,000. Ten large provincial companies receive annually £1,725,000, while their capital is only £5,756,000, or three and a-quarter times their revenue. The London Electric Supply Corporation in 1892 had an income of £24,282, with a capital of £836,000—equal to 34 years' revenue. This income, instead of increasing, was £4 400 less than that of 1891; and the expenditure exceeded it by £3,914, leaving a loss of this amount. Of the current generated, 58 per cent. was wasted in mains and transformers, leaving only 42 per cent. at the consumers' meters. But the distribution is now to be amended under the skilful guidance of Dr. Fleming; and the Directors hope that the "unaccounted for" current will be reduced to 30 instead of 58 per cent. But even this reduced amount looks formidable enough to the eyes of a gas engineer. As a specimen of waste, I may mention that the outlay on instruments alone (exclusive of meters and transformers) was £12,000—not far from a half-year's income—which would be much the same as if the Chartered Company were to spend £1,500,000 on pressure-gauges, governors, photometers, &c. I think I may promise for Mr. Methven that he will not advise such an outlay.

I sincerely regret the evil fortune that has attended this great experiment, which seems to have been dogged by ill-luck from the commencement; but even under the most favourable circumstances, success could not be expected for a design planned on such extravagant lines. It may have been "magnificent," like the Balaclava charge, but it was not a serious campaign. Mr. Ferranti—the general who set the squadrons in array—seems to have exercised a spell-like witchcraft over the first Board of Directors. Now, under the financial management of Mr. Staats Forbes, I trust the affairs of the Company may improve, especially as at Deptford he is seconded by Mr. D'Alton, an able practical engineer, who has already introduced valuable improvements, and has, moreover, the crowning virtue of being an *Irishman*, of a lineage which, to judge by my own experience, will not be without its value in your eyes.

But dismissing, for the present, this case of wild extravagance, let us see what the average result of such investments has been. That Cyclopædia of Science called the "Electrical Trades' Directory for 1893," so admirably brought out by the publishers of *The Electrician*, is the latest authority I can refer to; but, as the campaign of 1892 was not closed when it was compiled, I must take the profits of the year 1891. From October, 1878 to 1882, 56 companies were floated, with a total capital of nearly 21 millions. More than half of this was paid up, and nearly all has been lost. At the close of 1892 the electric light companies of the metropolis had a capital of £5,250,000, of which £2,700,000 had been paid up. The total profit for 1891 was £25,000, or less than 1 per cent. At the same time, the electric manufacturing companies had a capital of £4,750,000, of which £2,700,000 had been called up, and earned a profit of £211,000, or nearly 8 per cent.—a fair, but still moderate, profit on a fluctuating business. I have excluded the Edison-Swan Company, who only make lamps, and the Woodhouse and Rawson Company, which declared a dividend of 15 per cent., and were practically bankrupt the year after.

I will give an example of a town where gas and electricity have been in competition for over ten years—Eastbourne—which has, therefore, the benefit of accumulated experience—an experience so valuable that the officials of the Electric Company wish to keep it all to themselves, for they have refused to give a copy of their balance-sheet to a ratepayer who had contributed his quota to the public lamps which they supplied. This was a foolish attempt to conceal what could not be hidden. The total capital of the Company amounts to £37,000, of which only £400 is preference, on which, I believe, a dividend has been paid for some time: but this year the ordinary shareholders have for the first time been accorded a dividend. Charging 9d. per unit, the balance of profit and loss is £431, of which £233 is brought forward from a previous account, leaving the annual profit £198. But £169 of this arose from the sale of fittings, and £25 was received for a pupil's fee. If these two sums be deducted, we find the profit on electric lighting amounts to £4, for earning which the Directors justly received

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£250—too small a remuneration, when we consider the anxiety of mind caused by trying to navigate a craft so unseaworthy amidst shoals and breakers. They are now calling for more capital to be invested in this mine of gold, "this potentiality of wealth beyond the dreams of avarice," as Mr. Preece calls this "great industry." Why do the Directors not ask him to devote some of the abundant leisure which he has to spare from his official duties, and by his divining-rod find this hidden vein of gold into which they have not yet sunk a shaft? In this same town of Eastbourne, when the electric light was started in 1882, the consumption of gas was 90,584,000 cubic feet; in 1887, 146,068,000 cubic feet; and in 1892, 207,036,000 cubic feet—an increase of 107,452,000 cubic feet, or over 107 per cent. Thus was this "spotted snake" strangled by the "Herculean infant." An old Cork rhyme runs thus :—

It is better to fall with your back in a set of furze
Than venture to play with those ticklish things, *metaphors*—

rhyme *and* reason which I commend to Mr. Preece. I may remark that this engineer has recommended the Corporation of Bristol to charge 6d. per unit, being 1,800 per cent. over what he says electricity could be supplied at "if the load factor was uniform."

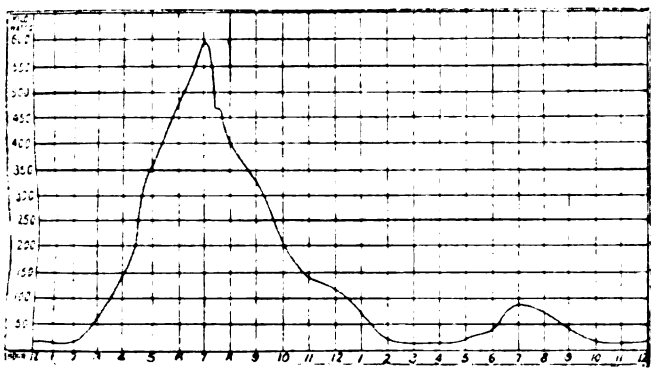
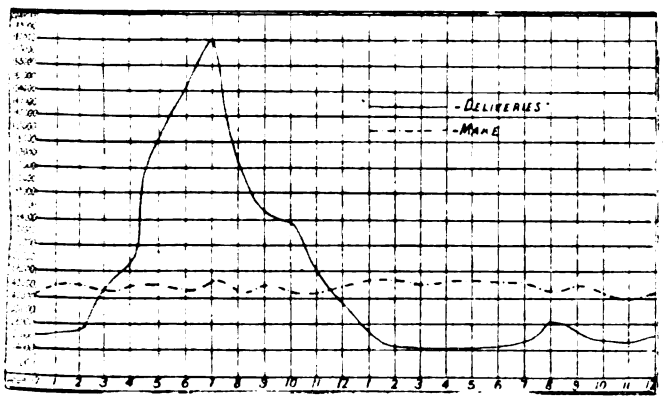


Diagram Showing Electricity Supplied from a Central Station in Midwinter.



Gas made in 24 hours, 1,174,000 cubic feet.
,, delivered, 1,263,300 cubic feet.

Diagram Showing Make and Deliveries of Gas from the Cork Gas-Works on December 23, 1892.

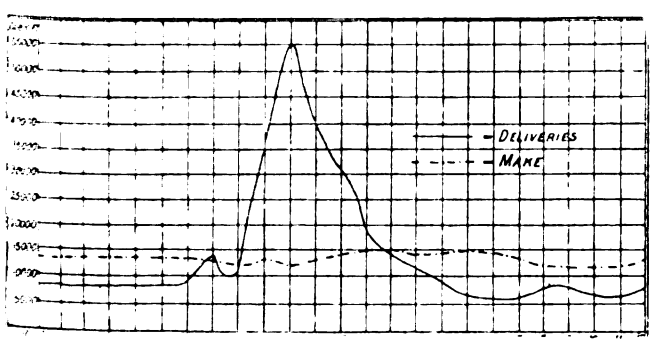


Diagram Showing Make and Deliveries of Gas from the Cork Gas-Works on June 22, 1892.

It is, I think, Mr. Crompton who first invented the very useful term *load factor*, meaning the ratio between the average and the maximum delivery of electricity. Of course, gas engineers have a load factor of a somewhat similar kind, but their system of storage enables them to put by the surplus of the day production to help the hours of darkness. With the alternating current, no storage is possible; and hence, if the dynamo ceases to work for even a few seconds, all lights are extinguished. With the continuous system, accumulators afford a partial but a very expensive and wasteful remedy. If we put 100,000ft. of gas into a holder, and got only 85,000 out, we should say things were going on very badly. Yet this very bad result is the very best claimed for storage cells, and in some cases the loss, I believe, is 40 per cent. The lot of the gas manager is also made more easy by the fact that a large percentage of gas is used by day for heating, cooking, motive power, and manufacturing purposes, thus filling up, to some extent, the deep hollow of the electric diagram. The sudden rise and the sudden fall of the curve produce the greatest difficulty which meets any system unprovided with storage power; indeed, some of the statements under this head are startling. Prof. Unwin states that within the 24 hours the demand varied from four times the mean to one-twentieth of the same quantity; that is to say, that the maximum was 80 times more than the minimum output. Even in gas distribution the maximum is 50 times as much as the minimum hour.

The latest authority is Prof. Ayrton, who, in his monograph prepared for the British Electrical Section of the Chicago Exhibition, states that the average hours of consumption of the electric light in private houses is only 1 hour in the 24, in shops and flats only 1½, and that it is only clubs and theatres that exceed this limit. Let us see the result that this leads to. He says that the whole of the electric lights fixed in Great Britain are equal to 750,000 8-candle lamps. Allowing even 800,000 lamps, this would be equal to 400,000 16-candle lamps, and, allow even 1½ hour, would mean 600,000 lamp hours, which could be supplied by 600,000 × 5 = 3,000,000ft. of gas a day, or equal to 1,100 million feet of gas in the year. This is less than the Brentford Gas Company sells. The town of Nottingham consumes more, and the combined consumption of Plymouth and Portsea is considerably more. The total sales of gas in London are 30,000 million cubic feet. The annual increase lately has been about 6 per cent., or 1,800 millions, so that the increase of gas consumption in London alone in one year would give one and a-half as much light as the whole electric lamps of Great Britain.

If we were situated near the Equator, the variation of the days would not be so great; and if we worked at night and slept by day the load factor would be much more convenient for us all. Or if we lived near the North Pole, we might work our dynamos for half the year, and let them sleep beneath the midnight sun for the other half. But placed as we are, where the seasons' change is so wide, this load factor becomes a burthen indeed. Make the case your own. Suppose that you had no gas storage, then in the lightest hour you should have as many retorts heated as may be required for the supply of the heaviest possible demand; for it is the *maximum hour's* consumption you should be prepared for, and in many cases the electrician has practically to provide, not for the maximum hour's, but for the maximum minute's output.

I have said that, besides the great aid that you derive from storage, your load factor is greatly alleviated, and your feelings soothed, by the fact that every year the "day" consumption of gas for heating, cooking, power, and other manufacturing purposes increases, while the lot of our younger rival is not yet made happy by such consolatory aids. Mr. Methven, in his recent interesting address, has shown that in the district of the Chartered Company the consumption of gas from 6 a.m. to 6 p.m. has been 37 per cent. of the total; and in other London districts a little under 30 per cent. Of course, we have heard of electric cooking, and I have seen the amusing experiments on this subject; but this and electric heating are reserved for that happy class "who have more money than they know what to do with."

Mr. J. Ferguson Bell, of Stafford, gives the following as the respective costs of one million heat-units :—

Gas at 2s. 3d.	40d.
Electricity at 4½d. per unit	1,301d.

The latter being 32 times as dear as heat produced by gas. Electric motors for very small powers will, I expect, come into use; but for anything above ¼ or 1 H.P. it is not likely that people will pay a price so much higher than gas power costs. On this subject I again refer to the authority of Mr. Bell, who gives the following figures :—

Cost of gas power at 2s. 3d. = 0·675d., say, ⅔d. per H.P.
,, electricity ,, 4½d. = 4 500d. per H.P., or, say, 6⅔ times the price of gas power.

Let us now examine what modes have been proposed to get over this difficulty; and, at the outset, it is as well to say that no plan has ever been devised to store electricity itself. The garnering up of other forces forms the only mode of meeting the difficulty of the fat kine and the lean kine—of the brief harvest and the long winter. These forces have afterwards to be transformed into electricity.

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First—to begin with the storage cell—no electricity is stored there. It is chemical energy which is laid up. If I take a piece of carbon and a piece of zinc, connected by a good conductor, and place them in an acid, well-conducting and easily-decomposed liquid, the zinc will first be oxidised; and the oxide so formed, combining with the acid, will form a soluble salt. When the zinc has all been dissolved, I place a second carbon in the solution, and send through it a current of a strength sufficient to decompose the salt, when the metallic zinc will abandon the acid and be deposited on one of the carbons, leaving the free acid in solution. We have, therefore, what we began with—zinc, carbon, and an acid solution; and, connecting the zinc and carbon as at first, we begin the series again, and repeat it as often as we like, the zinc being alternately oxidised and deoxidised. This is precisely what occurs in the so-called storage battery. The lead compounds are alternately deoxidised and again oxidised, thus alternately absorbing and envolving a current. In both the cases referred to the oxidation of the metal produces a current, and then an independent current produces deoxidation. As far as I can recollect, Sir William Grove, to whom science owes so much, was the inventor of the first storage system, which he called a "gas battery." A current was passed through two platinum plates and decomposed water—in fact, deoxidised hydrogen—the hydrogen and oxygen being collected in separate tubes. The battery wires were then removed and the two platinum plates connected by a wire passing through a galvanometer, when a current was observed to be produced by the reoxidation of the hydrogen and the reconversion of the gases into water. Gaston Planté discovered that, by alternate oxidation and deoxidation of plain lead plates, similar effects were produced. Then came the innumerable forms of the Faure-Sellon process, in which the lead plates were "pasted" with oxides of lead already formed. Yet I believe that, taking into account durability, no system has yet been invented better than the original Planté process, still surviving in the Howell-Crompton and other systems of accumulators. I have said so much in order to show clearly that in these cells there is no storage of electricity. Indeed, it would be wonderful if any prison could be designed to confine a spirit, not "airy" but far more subtle—in face, "ethereal." As electricity has even disdained the chain of a definition, it does not seem likely that it will be "cabined, cribbed, confined" in any material cell. It passes the wit of man to devise the cunning cage that could confine such a wild bird. These storage cells are undoubtedly often of great use in supplying a small output during the hours of lowest consumption, leaving engines and dynamos at rest for many hours. They are also of use during the hours of heaviest duty, and particularly in steadying the current when the dynamos are running. They are, however, enormously expensive, and occupy a very large space; and I believe there have been explosions caused by the hydrogen evolved. Mr. Kapp, in his lecture at the Society of Arts, puts down their prime cost at £40 to £50 per kilowatt; and as 1,000 cubic feet of gas are equal to 30 kilowatts, we have thus £1,200 to £1,500 for storage, as against £12. 10s. for gas. Mr. Kapp referred to comparatively small plants; and, I believe, for large central stations the capital would be less. But even if it were reduced to half, the cost of electric storage would be still 50 to 60 times as dear as gas storage. In addition, the depreciation is very heavy, and, with wear and tear, maintenance and interest, would sum up to 15 or 20 per cent. Their disadvantages are fourfold:—

(1) Heavy outlay on capital.
(2) Very large space occupied.
(3) Heavy cost of maintenance.
(4) Loss of current, which, in the most favourable circumstances, amounts to 15, and is often over 40 per cent.

They can never be used economically, except as auxiliaries—a kind of very heavy dragoons, to guard the flanks of the main column.

Two other modes of storage have been recommended by very eminent professors; and nothing can more clearly emphasise the difficulty to be encountered than the fact that systems so complex, so expensive in construction, and so wasteful, should be even thought of.

Prof. Forbes, having to deal with the case of Edinburgh—a place possessing for such a system natural advantages such as no other city in the British Islands enjoys—proposes to pump water for all the 24 hours, if necessary, to a reservoir situated at a great elevation, thus storing the potential energy of the elevated water. The water so stored is to actuate during the lighting hours turbines driving dynamos to produce the current. The natural advantage which Edinburgh possesses is this—that within 1½ miles of the city, it has, on Arthur's Seat, a natural reservoir at an elevation of 800ft., and the capacity of this reservoir can be extended. As it exists at present, this reservoir can hold sufficient water to supply 1,000 H.P. for two hours.

For motive purposes, the efficiency of a reservoir is the product of two factors—vertical height and capacity—the number of foot-pounds got by multiplying the elevation in feet by the number of pounds of water stored. Some strange mistakes have been made on this subject, and owners of water-power have imagined that they have had what they called "a fine ponding power," when it really has been of very small amount. A good many years ago I devised the following very convenient formula, which some of my friends have associated with my name. In it I have assumed that the efficiency of the water motor is 75 per cent., a very fair allowance when losses by friction, part-gate, &c., are taken into account. The formula is this: "One acre of water, one foot deep, gives one horse-power for one hour for (each) one foot of fall."

This tells us at a glance how large the impounding reservoir must be unless the elevation be very great. Prof. Forbes has, therefore, at Edinburgh, the unusual good chance of a ready-made reservoir at a very great elevation, and very near the city. Yet, under these circumstances, let us see what the losses may be, independently of the fuel used by the engine which drives the pumps.

First, the efficiency of the pumps themselves (including leakage of valves) cannot, I suppose, be higher than 85 per cent.; friction of rising main, which, being continuously at work, may be of smaller dimensions than the falling main, may cause a loss of 10 per cent.; for delivery main, say the same; efficiency of turbine, 75 per cent. Of course, I do not take account of efficiency of dynamo, which would be the same as if it were driven directly by steam-engine. The ultimate efficiency would, therefore, be $0{\cdot}85 \times 0{\cdot}90 \times 0{\cdot}90 \times 0{\cdot}75 = 51$ per cent. We should also count for interest and depreciation, say, 15 per cent. on the pumps and turbines, and 6 per cent. on the mains, and 5 per cent. on any outlay required for the extension of the impounding reservoir, besides rent and cost of "way-leave."

Against this the economies would be the cost of smaller steam-engines (worked, however, for longer hours), and the saving of fuel lost in getting up and letting down steam. We have also to look to the additional contingencies which arise under this system. The bursting of a main, the break-down of the pumps, the sticking of a valve, the choking of the turbines—any one of these events would stop the supply of light. Even in the very favourable position of Edinburgh, I cannot see that this system commends itself to engineers.

(To be continued.)

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June* 2, 1893.

The Late Prof. Moses G. Farmer.—Prof. Moses G. Farmer, whose death at the age of 73 occurred in Chicago on May 25th, was one of the earliest pioneers in the electrical field in this country, and was one of the best-known American electricians. After his graduation from Dartmouth College, in 1844, he exhibited an electro-magnetic engine of his own invention for the miniature railroad in connection with a lecture on electro-magnetism, and at the same time illustrated the application of the electric current to the explosion of torpedoes and submarine blasting. For a number of years he devoted his attention to telegraphic work, perfecting a fire-alarm system, and devising a system of multiplex telegraphy, and the printing telegraph, operated by an electro-magnetic motor. He lighted his own house in Salem by electricity in 1859, and it was said to have been the first house thus illuminated. During 1865-6 he invented what is known as compound wire, that is, wire having an iron or steel core with a copper cover. Later he made many important improvements in dynamo-electric machines, one form of which is the well-known Wallace-Farmer machine, and another form which is still used for torpedo work in the Navy. In 1872, he accepted the position of electrician at the United States Navy Station at Newport (R.I.), where he remained until 1881, when he was obliged to retire on account of ill-health.

The Tesla Lecture.—The publication of the lecture delivered by Mr. Nikola Tesla before the Franklin Institute, and later before the National Electric Light Association, at St. Louis, has been awaited with the greatest interest in this country, not only by fellow workers in the same or similar fields, but by electricians in general, and by the great mass of the electrical public, who would naturally not be expected to manifest any special interest in such work.

The General Electric Company.—The publisher of *Electricity* has been indicted for criminal libel by the General Electric Company.

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CORRESPONDENCE.

THE PUPIL SYSTEM.—A SUGGESTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The pupil controversy, which was recently raging, or, more accurately, sauntering along, in some of the papers has apparently died a natural death. I should like to suggest that firms, taking in (in the common sense of the phrase) a large number of pupils, should devote the premium of one of them, say £100 a year, to a skilled workman, whose duty would be similar to that of a workshop instructor in any of our technical schools, *i.e.*, he would go the rounds of the pupils every day, and explain anything in the way of fitting or the use of tools on which they might be engaged, and would be accessible to them at any time when they should happen to be in difficulties.

This would be an advantage to both foreman and pupil, for whilst the former's chief complaint against the latter is that he is constantly stopping the men's work to ask them questions and get assistance, the latter soon discovers that information can only be obtained by considerable coaxing and promises of "drinks," which sometimes mount up to an alarming total.

I cannot see that there would be any difficulty in obtaining the services of an "instructor," as there are men in all works who add to their incomes by performing these duties unofficially. From whatever point of view it is looked at, it seems to be a better plan than the present one, or rather, the absence of plan which at present exists for imparting knowledge to the pupil, who, I venture to think, has a right to expect some such assistance in return for his premium.

It is to be hoped that some firm will try the experiment, which cannot do any serious harm, and the pros and cons will be brought to light more fully than they possibly could be by any amount of ink-slinging.—Yours, &c.,

June 14, 1893. DISCIPULUS.

THE PRICE OF ELECTRIC SUPPLY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In a leaderette in your issue of 9th inst. you refer to the fact that none of the systems of charging at present adopted by electric supply companies tend to encourage a day load—that is, of course, excepting the St. Pancras plan.

It seems to me that the day load is (for continuous currents) to be looked for in a large extension of the use of accumulators close to the lamps they are to light. With accumulators at present prices, the arrangement is feasible, as shown by the figures below; while improvements and reductions in price will still further facilitate matters.

We may take it, I think, that a supply company could now contract for a number of accumulators at the price of £2 per 16 c.p. lamp, to be supplied for, say, five hours, and in a large number of buildings to be lighted there would be no difficulty in finding a cellar or out-house that could be used as a battery-room. The batteries might be provided and looked after by the supply company, the consumer paying a reduced charge for current and a rent to cover interest and maintenance expenses, or simply getting a small reduction in price if he allows the battery to be placed on his premises. It would, of course, be advisable that the batteries should be charged by a special system of mains, which, owing to the long time allowable for charging, need be of only small size, and would be connected to the charging dynamos only during convenient hours. The house-circuits would be supplied through automatic variable resistances, or would be controlled by automatic switches, which would keep the pressure at the lamps constant. The batteries being all in parallel, any consumer requiring an extraordinary amount of lighting would be partly supplied from his neighbour's stores; but, as the meters would be fixed on the separate house circuits, this would harm nobody. Where circumstance suited, of course one battery might be arranged to supply a group of houses. Now, consider the question of cost. We will assume that the charging current can be supplied during the day at such a price that the energy taken from the batteries will be charged for at half the rate for lamps run directly from the mains, and that the charge per 16 c.p. lamp per annum comes out at 10s. and 20s. respectively. Taking the case of a building containing 50 lamps, not more than 40 of which are, excepting under quite abnormal circumstances, lighted at once, we have:—

Cost of accumulator to run 40 lamps for five hours, £80; annual interest at 5 per cent., £4; annual renewals at 7½ per cent., £6; making the annual cost to consumer:

Without accumulator, 40 lamps at 20s.				£40	0	0
With accumulator, 40 at 10s.	£20	0	0			
Interest	4	0	0			
Renewals	6	0	0			
				30	0	0
Annual saving by use of accumulator (=25 per cent.)				£10	0	0

If, instead of having the batteries always in connection with the charging mains, it was arranged that each house had to disconnect from the mains before any lamps could be lighted, the charging might be done at, say, 300 or 400 volts, and a corresponding saving in the cost of mains would result. Of course, if each house had to rely solely on its own battery, this would have tobe somewhat larger than if others could be drawn upon occasionally.

As regards the estimated charge for day current, if the St. Pancras Vestry can afford to supply motors at half price between fixed hours, a further small reduction could certainly be made if the supply was to be given only at convenient times.—Yours, &c., W. S. BOULT.

60, Castle-street, Liverpool, June 13, 1893.

AUTOMATIC TRANSFORMER SWITCH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to your brief notice of our "Automatic Transformer Switch" in the current number of your paper, we should like to point out to your numerous readers that the impression conveyed therein is rather misleading in certain details, and requires the few following explanations:—Firstly, the trains of clockwork are delicate relay mechanisms, which are automatically re-set by the action of the switch, and *do not require any attention*. Secondly, there is only one moving contact and one resistance switch (which is rendered sparkless by three small coils), in addition to the primary and secondary switches. Thirdly, the true action of the apparatus is as follows:—When first the primary and secondary circuits are completed, sufficient energy is stored up (from the secondary) in a few moments to "switch off" *and* to "switch on" again; switching off the last light releases a portion of this stored energy, and switching on a light again releases the second portion of energy.

It is further proposed to replace the weak primary battery by a condenser or high resistance across the primary switch terminals. Where transformers are fixed in each house in combination with this switch, a saving of at least 8 per cent. on the total electrical horse-power generated at the station would be effected.—Yours, &c., NEW AND MAYNE.

Palace Chambers, 9, Bridge-street,
Westminster, S.W., June 12, 1893.

LEGAL INTELLIGENCE.

White v. Tussaud.

The defendant in this action applied on Wednesday last to the Court of Appeal for a new trial, alleging misdirection.

The case was originally heard on April 24th last, and resulted in a verdict for the plaintiff, Mr. T. M. White, an electric light contractor, who originally claimed £762. 16s., balance of an account of £1,072. 16s. for fitting up for the electric light a waxwork gallery for Mr. Louis Tussaud. There was a charge of £699 for installing 466 lights, and for extra work done an additional sum of £373. 16s. was claimed. Defendant had paid £310. The contract was entered into in November, 1890, but in April, 1891, a fresh contract was made to include the work already done, and also further work for which an order was given. In the month of June following a fire broke out at the gallery and prevented the carrying out of the contract. Defendant contested the claim upon several grounds, alleging that it was never agreed that 30s. per lamp should be charged, that the work under the first contract was never carried out, and that such work as was done was very badly done. The jury in the action found that the work contemplated by the first contract was duly performed, and gave a verdict for the plaintiff for £583 and costs.

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the difference between that sum and the amount of the claim being on account of deductions for lamps supplied, but taken back again by the request of the defendant.

Counsel having argued the case on Wednesday and Thursday, the Court dismissed the appeal with costs.

The MASTER OF THE ROLLS said if nothing had happened to take away plaintiff's rights under the first contract, and if he did all the work which that contract obliged him to do, then he must be paid for the work which he did according to the terms of that contract. There was distinct evidence that the work was done, that the 466 lights were put in, and the extra work in connection with them carried out. But there was a new contract made between the parties, and the question was, Did the existence of that new contract under the circumstances do away with the plaintiff's rights under the first contract? In his view, where there was a pending contract, and a second contract was made after the fulfilment of the first in respect of the same subject-matter, *primâ facie* the second was not taken at that moment as satisfaction of the first, but was only taken as satisfaction of the first when the second was completed. As a matter of evidence it lay upon those who asserted that the second was taken at the moment it was agreed to as satisfaction of the first to prove it; it was so contrary to all ordinary views of business. And unless they proved it clearly, it would always be held by all courts and all juries that the making of the second contract was not taken as satisfaction of the first. It seemed to him that the learned Judge made clear to the jury the question they were to try, and they found a verdict which could not be set aside. Therefore the appeal must be dismissed with costs, and the verdict and judgment must stand.

Verdict accordingly.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The Midland Railway Company invite tenders for the erection of buildings for their electric light machinery at Sandon Dock, Liverpool. These tenders have to be sent in to the Secretary of the Ways and Works Committee, Derby.

——— The Greek Government are inviting tenders for the necessary telephonic apparatus required for from 200 to 300 subscribers in Athens and the Piræus. The Telegraph Department will furnish the necessary posts, and all other materials may be imported by the contractor duty free. The work is to be carried out under the supervision of a State Committee, whose decision in all matters in connection with the tender will be final.

——— The Highland Railway Company invite tenders for various stores, including telegraph instruments, fittings, telegraph construction material, galvanised wire, lamps, lubricating oils, iron castings, &c., &c. Tenders must be lodged with the secretary, Mr. And. Dougall, at the Company's offices, Inverness, not later than Saturday, the 24th inst.

——— Tenders are required for lighting the Victoria Pier, South Shore, Blackpool, for which plans and specifications can be had of Mr. Harker, 78, King-street, Manchester, on or before the 17th inst.

TENDERS ACCEPTED.—The tender of Messrs. Pritchetts and Gold has been accepted by Messrs. Lambert Bros., for a complete electric lighting installation at their coal hoists at the Galleons, Royal Albert Docks, London, E., for the sum of £625.

——— The Portsmouth Town Council have accepted the tender of Mr. J. R. Penning for keeping in order the electrical apparatus at their pumping station, at £30.

APPOINTMENTS VACANT.—The Electric Lighting Committee of the Borough of Kingston-upon-Hull are prepared to receive applications for the appointment of Resident Electrical Engineer to take charge of their electric lighting station, at a salary of £250 per annum. Some particulars are given in our advertisement columns, and all other information can be obtained of Mr. R. Hill Dawe, town clerk, Kingston-upon-Hull. Applications must be in before noon of Thursday, June 29th.

——— The Vestry of St. Mary, Islington, require an electrical engineer competent to prepare plans and specifications in connection with the installation which the Vestry are about to inaugurate. Some further particulars will be found in our advertisement columns, and applications must be sent in to Mr. Wm. F. Dewey, the Vestry Clerk, Vestry Hall, Upper-street, London, N.

APPOINTMENT.—Mr. George H. Cottam has been appointed electrical engineer to the Hanley Town Council at a salary of £200 per annum. There were sixty-four applicants, ultimately reduced to four, from whom Mr. Cottam was finally selected.

PERSONAL.—We are asked to state that Mr. P. C. Middleton, late manager of Messrs. Walter Andreae and Co., has joined the staff of Messrs. New and Mayne.

MR. ROBERT W. PAUL.—We have to acknowledge the receipt of List No. 5, giving illustrated descriptions of the instruments manufactured by this firm. Descriptive illustrated price lists Nos. 1 to 6 can be obtained on application.

BANKRUPTCY.—A first and final dividend of 11d. in the £, in the estate of James Collins, formerly carrying on business as an electrical engineer at 80, Church-road, Hove, is payable at 7, Pavilion-buildings, Brighton, on the 21st inst.

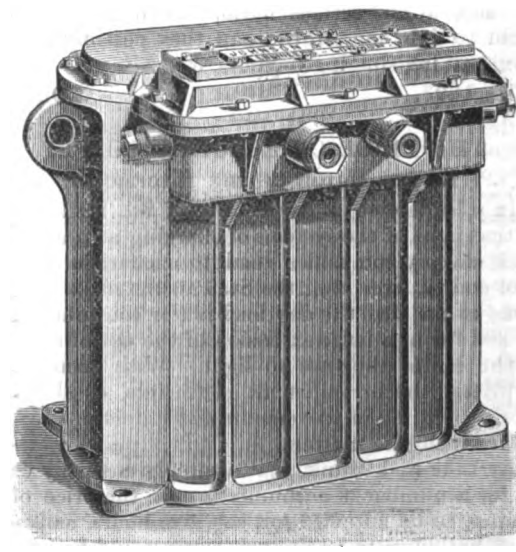
MOUNTAIN'S WIRE MANUFACTURING COMPANY (LIMITED).—The accounts filed under the winding-up proceedings of this Company show total liabilities £6,754, of which £3,042 are expected to rank. The assets, valued at £3,711, are absorbed by the claims of the debenture-holders, and the total deficiency as regards contributories is returned at £18,872. The failure of the Company is attributed by the Directors to bad management and to insufficiency of working capital. Mr. Mountain, however, attributes the failure to excessive working expenses, bad trade, and consequent low prices.

DISSOLUTION OF PARTNERSHIP.—Messrs. Young and Harrison, trading as the Economic Telephone and Electric Supply Company, at 58, North Corridor, Royal Exchange, Manchester, telegraph contractors, have dissolved partnership. Mr. J. R. Young, who continues the business, will pay all debts.

FIRE.—On Sunday morning a serious fire occurred at the generating station of the Morecambe Electric Light and Power Company (Limited), Morecambe, Lancs., by which damage was done to the extent of about £350.

LUBRICATING OILS.—Messrs. W. H. Willcox and Co., of Southwark-street, S.E., have just issued a new price list of their lubricating oils, which can be obtained on application. Accompanying the list are illustrations of the special makes of lubricating oils, lubricators, oil filters, &c., made by the firm.

MESSRS. JOHNSON AND PHILLIPS' TRANSFORMERS.—This type of transformer is the outcome of considerable experimental work,



including the testing of various qualities of iron, and has resulted in a most satisfactory and approved design. The makers inform us that the magnetising-current is very small, and the drop of volts between no load and full load is considerably less than in other transformers. The case is made of cast iron and is perfectly water-tight, glands being provided for both the high and low-tension leading wires. Stock transformers are of the following voltages:—From 2,400 volts to 100 or 50 volts; from 2,000 volts to 100 or 50 volts; and from 1,000 volts to 100 or 50 volts.

MESSRS. NALDER BROTHERS AND CO.—This firm are now making mirrors for galvanometers and other purposes, and have added a department for general optical work.

THE HOOK OF HOLLAND.—The Great Eastern Railway Company have sent us a pamphlet and a guide book of this new route to the Continent. The Hook of Holland is at the mouth of the Maas, and the traveller thus avoids the journey up that river to Rotterdam. The books contain all particulars about the route except the fares and the length of the passage.

THE ROYAL WEDDING.—Among the suggestions for illuminations on the occasion of the Royal Wedding on July 6th, it is proposed that special illuminations of the Mansion House, Tower Bridge, St. Paul's Cathedral, the Bank of England, the Law Courts, Somerset House, and other large public buildings *en route* to Liverpool-street Station should be effected.

TELEPHONE SUBSCRIBERS.—The New Telephone Company send us their latest list of Manchester, Bolton, and Eccles subscribers.

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TELEPHONIC EXTENSION.—Llandudno and Colwyn Bay are being connected by telephone, and a new Exchange will shortly be opened by the National Company at the Central Chambers, Colwyn Bay.—A trunk line is also to be constructed to Rhyl, and a Central Exchange is to be erected in that town.

WOODHOUSE AND RAWSON UNITED (LIMITED).—The following circular is issued by Mr. T. D. Leslie, the Receiver and Manager:—"Having had numerous inquiries as to whether the business of Woodhouse and Rawson United (Limited) is still being carried on, I beg to inform you that it is, and will be continued, under my personal supervision as Receiver and Manager on behalf of the debentures holders of the Company. I also beg to inform you that, with a view to centralising the business, I am, with the exception of Glasgow, Birmingham, Bradford, Manchester, and Kidsgrove, closing all other branches throughout the United Kingdom. This will enable the head office to keep in direct touch with the numerous customers of the Company and avoid that delay which must necessarily be caused by correspondence between the branches and the head office. The works at Manchester have recently been enlarged by new machinery, &c., having been put down, and I am pleased to say that the Company is now in a position to turn out work thoroughly and promptly."

ABERYSTWITH.—The *Cambrian News* states that if the Corporation would but stand on one side and throw the electric lighting of the town open to competition more than one electric lighting company has expressed its willingness to light the town.

BOLTON.—On a motion to adopt the minutes of the Gas and Lighting Committee of the Town Council, Councillor Tootill complained that he considered unnecessary delay had taken place in the introduction of the electric light, and he considered a great deal of the blame was attachable to the Vice-Chairman of the Gas and Lighting Committee. The Electrical Sub-Committee had, after visiting various parts of the country, sent in their final report; but notwithstanding this, visits had been made to other parts of the country, presumably to obtain further information. He knew of tradesmen who were delaying further expenditure pending the action of the Corporation, and he asked what was the actual position of affairs regarding the introduction of the electric light into the Borough. Councillor Cooper replied that a meeting of the Electrical Sub-Committee is to be held, and a final report would be sent in to the General Committee. It was explained that since the first report of the Sub-Committee was sent in an electrical engineer had been appointed, and it was the opinion of several members of the Committee that he should have an opportunity of seeing several of the electric lighting stations at work in order that he might advise the Committee on the subject. No time would be lost in pushing on with the work so soon as the final report had been approved by the Council. Another member anticipated that some time during the coming winter they would be in a position to supply the electric light.

BRIDGEND.—The Bill confirming the Bridgend Provisional Lighting Order has been before the examiners of the House of Lords, and has passed for second reading.

BRISTOL.—In connection with the Industrial and Fine Arts Exhibition, of which some particulars were given in our last issue, we are informed that it is proposed to make a special exhibit of electroliers, brackets, &c., suitable for the lighting of the Fine Arts Section, free of charge, to firms willing to loan such fittings, the object being that intending consumers of the current, which will shortly be supplied by the Corporation, may have facilities offered them for selecting such fittings as would be likely to meet with their possible requirements. The number of fittings which the Lighting Committee of the Corporation, who had the matter in hand, are able to accept, must necessarily be limited. The Exhibition is to be lighted throughout by electricity from the city mains, and electric work in general is to be made a leading feature. The Exhibition will be opened about the end of August.

CHELSEA.—An exhaustive report by the Surveyor to the Chelsea Vestry, on the lighting of the main roads, has been presented, which the Vestry have ordered to be printed and circulated amongst the members. Reference is made to schemes for the better lighting of the district by electricity. The Vestry, at its last meeting, discussed the advisability of asking the Gas Light and Coke Company to reduce their charge for gas, in accordance with a promise made by the Chairman of that Company to a deputation which waited upon them last year. A deputation was appointed to wait upon the Gas Company.

CLAYBURY ASYLUM.—The new Asylum of the London County Council at Claybury, Essex, will be formally opened to-morrow (Saturday), by Mr. P. M. Martineau, at 3:30 p.m. The building will accommodate 2,000 inmates, and includes workshops for various handicrafts for the male patients. The electric lighting installation is very complete, and consists of 4,500 incandescents. The architect is Mr. G. D. Hine, and the principal contractor is Mr. E. Gabbutt, of Liverpool.

DATCHET (NEAR WINDSOR).—The electric light installation at the Manor House, Datchet, which had been put down under the superintendence of Mr. Farrow, recently appointed Resident Engineer of the Windsor Electric Light Company, is now completed. A Crossley engine drives a Taunton dynamo, and another dynamo is fitted with two fly-wheels to run in parallel with a number of E.P.S. accumulators, which are included in the installation.

DERBY.—An Electrical Exhibition has been opened at the Derby Co-operative Hall, promoted by Messrs. S. Rowbottom and Co., and comprising samples of various makings of lighting plant, apparatus, &c.

DUNDALK.—The Commissioners have resolved to apply to the Board of Trade for a renewal of the Dundalk Electric Lighting Licence.

HALIFAX.—Councillor Braithwaite, at the last meeting of the Borough Council, proposed that such Committees of the Council as used telephonic, telegraphic, or electrical appliances of any kind, be requested to place the repairing, maintenance, alterations, or extensions of such appliances in the hands of the Borough Electrical Engineer, except such as are done by contract. It was pointed out this would necessitate the fitting up of an electrical workshop and other expenditure. After some discussion it was agreed that, attention having been called to the matter, the motion should be withdrawn.

HAMPSTEAD (LONDON, N.W.).—Thirty-one tenders have been received by the Vestry for providing the plant for the proposed electric lighting station in Finchley-road, and nine tenders for the erection of the chimney shaft, and buildings and foundations for the machinery. It was decided, at the last meeting, to advertise again for tenders for the erection of the buildings, and to postpone the opening of the whole of the tenders until the next meeting.

LEYTON.—The Local Board have authorised application to the Board of Trade for a Provisional Order, and the Electric Lighting Committee have under their consideration various estimates in relation thereto.

MOFFAT.—At the meeting of the Town Council, on Tuesday last, Mr. Brown submitted a report by Messrs. Woodhouse and Rawson, Glasgow, with respect to the lighting of the town by electricity. The report stated that by using the water-power obtainable at Skellywell, sufficient power would be obtained to light the streets of the town by 2,000 c.p. arc lamps, and leave to be sold to private persons current estimated to be worth more than £1,900 a-year. The current could be conveyed for the first mile and a-half through the fields by overhead wires, and for the last half-mile by mains. The estimated cost for the works and plant, exclusive of batteries or small accumulating stations required in the distribution to private houses, was stated as likely to be rather less than £3,900. The report is to be discussed at the next meeting of the Council.

MONTROSE.—Some time back the question of lighting this town by electricity engaged the attention of the Police Commissioners, and a Committee now recommend that the services of Mr. Bryson, of Glasgow, be obtained to advise them on the subject. Mr. Bryson agrees to give advice and a full report for £10. 10s.

NEWCASTLE.—At the last meeting of the Lighting Committee of the Council, the subject of the lighting of Grey-street came up for discussion, and it was decided to light this thoroughfare, including Grey's Monument, four lamps to be placed at the Monument and four in Grey-street, each of 1,500 c.p.

NEWPORT (MON.).—The Free Library Committee of the Local Board are discussing what system of electric lighting shall be adopted. The Chairman stated "that the heat caused by the gas was rotting the building."

OSWESTRY.—A meeting of the Town Council is to be held on July 3rd, to consider the application of the local Electric Lighting Company for the Board's sanction to their applying for a Provisional Order. The General Purposes Committee have decided to recommend that the application of the Company be acceded to.

RAMSEY.—The Fire Brigade Committee of the Town Commissioners require an electric fire call, and proposed at the last meeting that a vote for £30 should be granted for this apparently indispensable object. The Commissioners could not see their way to this expenditure until the matter had been further discussed by the Fire Brigade Committee, who are subsequently to report to the Commissioners on the subject.

ROTHERHAM.—At the last meeting of the Town Council the Mayor, in reply to a question as to when the electric lighting subject would be discussed, remarked that, in his opinion, "the question was dying a natural death."

RUGBY.—The installation at Rugby School will consist of about 1,500 incandescents. The generating plant is to be placed, as stated in our last issue, at the rear of the gymnasium, and a special type of gas engine is to be used, with Dowson's gas, which will be

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made on the spot. The engine is to be 100 H.P., with two impulses to each revolution, with which increased steadiness is anticipated. The lighting is, we understand, to be carried out on the co-operative principle, the house masters finding the necessary capital. It is confidently expected that the cost will be less than the gas and candle lighting now adopted, and that when the students return from the summer holidays in September the light will be in working order.

ST. ALBANS.—The subject of lighting St. Albans by the electric light is being discussed, and the Corporation will be asked to appoint a Committee for the purpose of considering the matter. It is probable the Corporation will decide to apply for a Provisional Order. Councillor Toulmin will propose the Committee, and as he "is not a gas shareholder, has the courage to move in the matter."

ST. PANCRAS.—The Electricity and Public Lighting Committee of the Vestry recently inquired into a temporary depression in the supply of electricity, which occurred on May 8th, the result of their inquiries being that the depression arose from insufficient stoking, the boiler fires having been allowed to get too low, so that when the heavy load of the evening came on, the boilers did not develop sufficient steam for the output required.——At the meeting of the North St. Pancras Ratepayers' Association, the action of the Joint-Committee, appointed by the Vestry, on the subject of erecting an additional central station in King's-road, was approved.

SCARBOROUGH.—Subject to the approval of Mr. Bernard Drake, the electrical engineer to the Town Council, permission has been given to the local Electric Lighting Company to lay their mains and complete the necessary work for the public installation. The Council discussed the alterations made by the Board of Trade in the draft deed for the transfer of the electric lighting undertaking from the Corporation to the Scarborough Electric Supply Company, the Council disapproving of the Board of Trade's alterations.

TIVERTON.—A letter was read at the last meeting of the Town Council by the Mayor, which he has received from Mr. Amory, a resident, suggesting that a Guarantee Society should be formed of those persons willing to adopt the electric light, in order to obviate any burden upon the ratepayers. He suggests the guarantee should be for three years, and that during that period tradesmen and others using the light should agree to pay 9d. per Board of Trade unit, and that a first charge upon the profits of the scheme should be a refund to the consumers of any sums paid by them exceeding 6d. per unit. The letter was very favourably received, and was ultimately referred to the Electric Lighting Committee for consideration.

WOLVERHAMPTON. — With reference to the electric lighting scheme, as stated in our last issue, Mr. F. Harman Lewis, late of Hull, has been appointed electrical engineer, at a salary of £300 per annum, and Mr. A. P. Brevitt, of Wolverhampton, has been appointed architect, to prepare plans and specifications for the necessary buildings in connection with the scheme, at an inclusive remuneration of 5 per cent. on the building contract. Mr. Brevitt designed the Oxford Station, a copper depositing works at Greenwich, and special works at Wednesfield for making phosphorus by electricity.

WORCESTER.—The Watch Committee have appointed Mr. W. H. Preece to supervise the electric lighting works, at a commission of 2½ per cent. on the amount of the Brush Company's contract.

YEADON.—The Local Board have decided to accept the offer of Messrs. Andrews and Preece (Limited), of Bradford, to furnish an estimate, free of cost, for lighting Yeadon electrically.

PATENT RECORD

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

May 29, 1893.

10,474. J. S. BOLTON and T. J. MURDAY. Gateshead-on-Tyne. Improvements in the construction and form of accumulators for the storage of electrical energy.

10,501. C. A. PRICHARD. London. Improved method of heating liquids by electricity.*

May 30, 1893.

10,533. J. T. JOHNSON. London. Improvements in electrical signalling and printing telegraph systems, and in apparatus employed therein. (Alfred Samuel McCaskey, United States.)*

10,569. R. E. BELL, CROMPTON, and H. J. DOWSING. London. Improvements in means or apparatus for regulating the temperature of electrical heating, cooking, or like apparatus.

10,584. A. T. CASTNER. London. Improvements in connection with electrolytic apparatus.

10,594. T. B. BROWN. London. A novel method of ornamenting or decorating the bulbs of incandescent electric lamps.

10,597. G. S. SLUCE. London. Improvements in devices for adapting electric lamps to ordinary candle fittings, and the like.

10,615. J. HINES. Liverpool. Improvements in telephony, or means for transmitting telephonic signals through long distances.

10,623. D. MURRAY. London. Improvements in printing telegraphs.

10,630. J. ODDY. London. An improved material or combinations of materials to be used for the manufacture of electric arc candles, applicable also for the manufacture of brushes or collectors of dynamos or electric motors.

May 31, 1893.

10,648. G. MITCHELL. London. An improved combined electric light and heat stove.

10,696. H. H. LAKE. London. Improvements in insulators for electric wires. (Eugen Hartmann and Wunibald Brann, Germany.)

June 1, 1893.

10,720. A. MATUSZKIEWICZ. Dublin. Driving tricycles and other similar vehicles by electricity.

10,765. E. J. CLUBBE and A. W. SOUTHEY. London. Improvements in secondary voltaic batteries.

10,772. G. H. CUTTING. London. Improvements in ceiling roses for electric connections.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

9,566. ATKINSON. Electric percussive tools.
9,748. SPENCE. Armature and transformer cores.
10,608. DRAKE and OTHERS. Electrical accumulators.
10,632. BRAIN. Electric switches.
10,855. KIRKPATRICK PICARD and ANOTHER. Secondary batteries.
11,050. COOK and PAYNE. Tubular electric conductors.
11,664. PAYNE. Electric conductors.
11,823. ARON. Measuring electric currents.
12,735. FULLER (J. C. and G.). Telegraph insulators.
12,807. MONEY and NASH. Electric arc lamps.
12,906. HADDOW and HUTCHISON. Electrical connections for ceilings.
13,072. RYLANDS and SLATER. Coupling and fixing glass tubes for electric wires.
13,095. VON POSCHINGER. Electric heating of pottery, &c., furnaces.
13,105. JOBSON. Attaching arms to telegraph poles.
13,146. FORBES. Microphones.
13,338. FORBES. Switchboard.
13,595. EWING and LAMB. Electric currents.
15,057. BROCKIE. Electric arc lamps.
15,120. HEADLAND. Electrical accumulators.
15,194. MAYER and JAMESON. Telephone transmitter.
18,160. ANNETT. Telephonic receivers.

1893.

2,586. WAITE. Diaphragm for electrolytic cells.
3,285. CLARKE. Electric railway signals.
3,676. MAYER. Telephone transmitters.
5,911. MANN. Electric contact maker.
6,468. SIEMENS BROS. and Co. (Limited) and NEBEL. Electric arc lamps.
6,703. KOCH. Dynamo brushes.
6,952. MITCHELL. Electrically heated crucibles.
7,758. KLOSS. Electric fire alarm.
7,865. THOMSON. Lightning arresters.
7,866. THOMSON. Lightning arresters.

COMPANIES' MEETINGS.

Consolidated Telephone Construction and Maintenance Company (Limited).

The twelfth annual general meeting of this Company was held on Monday, at Winchester House, Old Broad-street, under the presidency of Mr. C. L. W. FitzGerald.

The SECRETARY (Mr. Charles Curtoys) having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, we were a little late in getting the report out, but that was simply a question of the auditors. From that report you see that the profit for the year amounted to £4,861, and adding

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the amount brought forward, it makes £6,228 to be dealt with at the present moment. You observe, a little lower down in the report—some of you, no doubt, attended them—that we passed resolutions at extraordinary meetings for the payment of a certain sum of money for the preference shares and the ordinary shares which we received from the Austrian Company. If you look at the balance-sheet, you will see that the Austrian Company has paid us the sum of £47,675, leaving £2,325 more to pay. The reason for the delay in the payment of that £2,325 is purely a question of accounts, to be settled by the Austrian Company with the Austrian Government; and here I might remark that we called our meeting for to-day because we had hoped to have been in a position to tell the shareholders that we had received the sanction of the Court to return them that capital. However, you are, no doubt, aware that in legal matters you cannot hurry the lawyers. We have now been four months over the matter, and are told that it will still take another month. I now come to a paragraph in the report which I regret very much, for we are not doing so well in the manufacturing department as we have been doing. I can assure you that arises only from one cause; I will not say foreign competition only, because it is competition of English firms also. They keep cutting down the prices of telephones, and the Directors are absolutely powerless. We must sell at the reduced quotation, or not at all. It is an absolute fact that the volume of business turned out at the factory last year and this year was practically the same, but the profit is reduced from £6,000 to £1,848. That is a very serious item, but all we can do is to manage the business as economically as we can, and do the best we can for you. The whole of the Board are very largely interested in the shares of the Company. I myself have something over 7,000 shares, so you can imagine that we are anxious to do well for you. You will see that we have again given up half our fees for the benefit of the shareholders. So far as our agency business is concerned, I think we may be fairly satisfied, and also with the wire rental business. Of course, all these things in the beginning are very slow, but still the business is in England to be got; and if it were not for the foreign competition in the manufacturing department, I think that the affairs of the Company would look in a fairly satisfactory position. Our only remaining subsidiary company working a telephone exchange is the Anglo-Portuguese, which is doing fairly well, and steadily progressing. It pays a dividend of 5 per cent. on its ordinary share capital, in addition to paying us a dividend on the debentures we hold. I am pleased with the Anglo-Portuguese Telephone Company for this reason—that it has been a steady drain on this Company in finding it money up to date, and now we see that we are getting that money back. I think that that is a fairly satisfactory point. I do not think that there is any particular item to which I need call your attention in the accounts, excepting the one of expenses. They have been considerably reduced, and they will next year show a further reduction, for this reason—that in the present statement we only show one half-year of the reduction we made at the date of our last meeting. I might mention that we are owed the sum of £8,813, while we owe only £998. That, I think, is very satisfactory. You can see for yourselves that we have a very large sum of money in hand, which we hope to return very shortly to the shareholders. I now propose—"That the annual statement of accounts and balance-sheet, with the reports of the Directors and auditors, as now submitted to the meeting, be received and adopted, and that a final dividend, at the rate of £5 per cent. for the half-year, making £6 per cent. per annum, be paid on the preference shares, and £2 per cent. per annum be paid on the ordinary shares, for the year ending March 31, 1893, as therein recommended."

Sir A. ARMSTRONG, K.C.B., seconded the motion.

Mr. HIBBERT observed that he had nothing to say against the Directors, for he felt that they had done all they could. He thought, however, that they were working the manufacturing department at a loss. They were now going to pay off the preference shares and to write down the capital to £112,000, in 224,000 shares of 10s. each. If they made a profit afterwards on the present basis it would only amount to 2 per cent., and the question was whether it was worth while going on, unless the Chairman hoped—as he himself did—that there was some chance of extra profit coming to them. As far as he could see, the patents were altogether gone, and there was no goodwill now, and he did not think that they were justified in entering the item as goodwill.

The CHAIRMAN: The hon. shareholder has referred to a figure in the balance-sheet which we had absolutely nothing to do with.

Mr. HIBBERT said he was aware of this.

The CHAIRMAN: There is that £73,000 staring us in the face, and it was something beyond that, only we have reduced it. The figure was put there by another set of gentlemen altogether. If I had had anything to do with the Company at the time it would never have been put there. The shareholder suggested that it should be written down, but if you do that you must write down your capital on the other side. I do not know how that would meet with the approval of the shareholders. Personally, I do not care whether you have your shares at 5s. or 10s.; it is the profit on the shares that I look to. We are going to write off some of this item, however. As to the future, I do not care to be a prophet. I hope we shall do better, but it is very difficult to prophesy. I am not a merchant, and have not met with anything in the shape of foreign competition until now, and I must say that that competition is worse than I anticipated. If you take only the manufacturing and only the expenses on the other side, you are working at a loss; if you do not take the securities you hold as worth anything, then you are working at a loss.

Mr. WALKER inquired whether the Company had any claim against the National Telephone Company on account of its instruments.

The CHAIRMAN: No.

On the motion of Mr. BUCKINGHAM, seconded by Mr. ARTHUR BAKER, the retiring Directors, Mr. Fitzgerald and Mr. Henry Grewing, were re-elected.

Mr. BUCKINGHAM said that with respect to working at a loss, it was only fair to say that as the figure was shown, a loss was practically apparent. At the same time, it was not fair to charge all the expenses to the manufactory, and if that view were taken, a small profit would be shown. He hoped that their next balance-sheet would be found more acceptable.

The CHAIRMAN then proposed the re-election of Mr. J. G. Griffiths as auditor.

Sir A. ARMSTRONG seconded the motion.

A SHAREHOLDER said he desired to protest against the large fee that was paid to the auditors. The profit of the Company was very small, indeed there was almost a loss, and as the Directors had voluntarily given up part of their fees, he thought the auditors ought also to show some sacrifice. He proposed an amendment to the effect that only one firm of auditors should be appointed, and at the salary of 50 guineas.

The CHAIRMAN said that there was no absolute necessity for two auditors, but he had reminded the shareholders a good many times that in 1884 they desired to have two auditors. He thought that the shareholder was hardly in order in moving his amendment, as he had not given previous notice to the Directors of his intention to do so. The Board would, however, approach the auditors, and see if they would not reduce their remuneration.

Mr. J. G. GRIFFITHS said that he was not at all anxious to be re-elected, especially if there was the slightest dissent. The duties and responsibilities were considerable, and he was quite confident that his firm were not over paid for their work. He regretted that he was not able to accept a reduced remuneration, but he was prepared to retire at once if the shareholders wished it.

The CHAIRMAN said that, personally, he would regret losing either of their auditors, although he had said candidly that two auditors were not absolutely necessary.

Mr. GRIFFITHS said he would be very glad if Mr. Green's name were put first to the meeting, if it was only intended to re-elect one of them.

A SHAREHOLDER remarked that Mr. Griffiths had been an auditor from the first, and that his name ought, therefore, to be put to the meeting first.

The CHAIRMAN then submitted the name of Mr. Griffiths for re-election, and declared it carried with one dissentient.

A SHAREHOLDER afterwards proposed the re-election of Mr. Green.

The CHAIRMAN seconded the motion; but having put it to the meeting in the usual way, he announced that Mr. Green was not re-elected.

On the motion of Mr. WALKER, a vote of thanks to the Chairman was passed; and

The CHAIRMAN having briefly acknowledged the compliment, the proceedings terminated.

The following is the report of the Directors:—

The report and accounts of the operations of the Company for the year ending March 31st showing a net profit of £4,861. 17s. 10d., which, with the amount carried forward, leaves a balance of £6,2 8. 6s. 7d. for disposal, after making provision for doubtful debts. Your Directors propose to pay a dividend of 2 per cent. for the year on the ordinary shares, and 3 per cent. on the preference shares for the half-year, making 6 per cent. on that class of share for the year: writing off the sum of £357. 18s. 9d. for depreciation of plant, machinery, and furniture; also £63. 16s. 8d. from the cost of new building, and reserving £19. 11s. 9d. for rentals paid in advance, thus leaving a balance of £1,117. 13s. 6d. to carry forward. The Board regret that, though the volume of work turned out from the factory has been much the same as last year, the profit has been very much decreased by foreign competitors offering instruments at lower prices. The Directors have again unanimously resolved to relinquish one-half of their fees for the year ending March 31st. The agencies established have proved fairly remunerative, and the private wire rental business is showing satisfactory expansion.

The remaining subsidiary Company, the Anglo-Portuguese Telephone Company, in active operation in exchange work, has, considering the state of affairs in Portugal, done very well, the progress being shown by the following statement:—

Year ending March 31st.							
Subscribers.		Rental.		Increase.			
1892.	1893.	1892.	1893.	Subscribers.		Rental.	
2,139	2.249	£13,640	£14,447	110		£837	

Birmingham Central Tramways Company (Limited).

Mr. Joseph Ebbsmith, Chairman of this Company, has issued a circular to the shareholders, of which the following is an abstract:—

"Herewith you will receive notice of a special meeting, which will be held on June 21st, for the purpose of considering certain proposals to alter the Articles of Association of the Company. As your mind may have been disturbed by recent reports on the state of the Company's affairs, I desire to make this report upon the duties which you entrusted to me in 1887, and which I now claim to have fulfilled. When I became Chairman of the Company my efforts to avert liquidation were ridiculed. It was pointed out that the contracts and commitments of the Company far exceeded its available assets. This I admitted; but expressed my opinion that, with prudent administration, the earning capacity of the Company was sufficient to avert its collapse, even though it might not be sufficient to return the capital expended. In 1888 I was urged to reduce the capital of the Company, but I declined to recommend any such reduction.

"The present position of the Company is accurately shown by the fact that our engagements, which at one time were so serious, have been fully

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met. The whole of the capital commitments have been discharged. There is not at the present time a single obligation of the Company for which ample provision has not been made. We have repaid our bankers the advances which they made after full inquiry into the position of the Company, and we have now more than £24,000 of debentures available for issue if required. During the past six years the present Board have paid on capital account more than £160,000. The Company has paid its debts and has fulfilled its contracts; and the time (foreshadowed by me in 1888) has now arrived when the shareholders should calmly and dispassionately consider the question of reduction of the ordinary capital of the Company to the amount upon which a reasonable dividend may be certainly expected. I think you may safely disregard extreme opinions on this question of reduction of capital.

"In 1887 the working profits were under £20,000 per annum. In 1888 they rose to £30,000; and now an average of £45,000 may be reckoned on, which, after payment of rent, interest, and preferential dividend, allows an annual reserve of £10,000, and leaves £10,000 for division among the ordinary shareholders, representing 5 per cent. on £200,000; and I therefore recommend a reduction of the ordinary capital from £400,000 to £200,000, that is for each ordinary share to be £5 in lieu of £10. You will find a share paying 5 per cent. is more marketable than one paying only 2½ per cent., whatever the nominal amount.

"The meeting to be called is for the purpose of making certain alterations in the Articles of Association, which is necessary before a reduction of capital can be effected. No less than four meetings may be necessary—the first to authorise the alteration in the articles; the second to confirm the resolution; the third to determine by resolution the amount of the reduction; and the fourth to confirm that resolution.

"Let me assure you most emphatically that my impending resignation is not caused by anxiety as to the present position of the Company. The cause is purely personal, and the new Board may, at any time, rely upon my goodwill and readiness to advise them upon any question within my special knowledge. I would point out to my critics, whether friendly or unfriendly, that there is a local as well as a financial aspect of the work which I have done for the Company. Had the Company passed into liquidation in 1887, when the gloom of the Cab Company failure hung over Birmingham, the double catastrophe would have more than doubled the financial scandal. I took the chair, I pledged my tramway reputation that the Company was a solid profit-earning undertaking, and I have the satisfaction of knowing that my colleagues and I have not only saved a substantial amount (£5 per share means £200,000) for the ordinary shareholders, but have also done our best to avert a foul blow upon the commercial credit of Birmingham."

Accompanying Mr. Ebbsmith's circular is another dealing with certain statements made by a Mr. J. T. Mantle, acting as Chairman of a "Shareholders' Committee," censuring the Board for their action in introducing electricity into the Bristol-road section of their system "against the advice of the Company's engineers." This the Directors deny, and are supported in this denial by letters from both Mr. E. Pritchard and Mr. J. Kincaid, the engineers referred to. It appears to have been a question entirely of finance, £40,000 being the estimated cost of accumulator traction, and £80,000 for cable traction. The Directors contend that the then (1888-9) financial condition of the Company rendered it impossible to raise the larger sum.

The Shareholders' Meeting will take place at the Queen's Hotel, Birmingham, on Wednesday, June 21st, at 12:30 o'clock.

Elmore's Wire Manufacturing Company (Limited).

An extraordinary general meeting of this Company was held on Monday at Winchester House, E.C., Mr. F. J. Atkinson presiding.

The CHAIRMAN said the report of the Committee of Investigation appointed by the general meeting of the shareholders was issued in April last, when it would be seen that, if the working capital required was fully subscribed, there was every prospect of good success for the Company. The Board and Committee jointly made an issue of £25,000 of Six per Cent. First Mortgage Debentures, which, however, were insufficiently subscribed. The Board submitted a scheme to some of the larger shareholders, and this was approved, as would be seen from the resolution passed on a previous occasion. The provisional applications for the preference shares, however, had been comparatively few, and fresh negotiations had been opened up with other parties for an advance of the sum required to relieve the Company from its liabilities, amounting to £15,000. These negotiations had been carried on through Mr. Hay, whose offer stipulated that the Board should get the additional capital required to carry on the works without delay. It would be necessary, therefore, that the resolution referred to should be passed, and certain of the shareholders had agreed to assist the Board in the capacity of a consultative committee. The scheme would, in a measure, meet the views of those shareholders who contended that, as the preference shareholders were to take so large a share of the profits, only the least possible number of preference shares should be issued. The Chairman then submitted a resolution, that 16,500 unissued ordinary shares of the Company should be issued, to be called preference shares, carrying interest at the rate of 10 per cent. per annum, and to one-half of such remaining profits in each year as should be applicable to the payment of a dividend on the capital paid up on the shares of the Company other than the founders' shares; such preference shares to be entitled to priority not only as to dividend, but also as to capital on a distribution of the Company's assets.

The motion was seconded by Mr. ELMORE, and opposed by General BEADLE and Mr. BARKWORTH, but eventually agreed to.

A consultative committee of shareholders was appointed to confer with the Board.

Printing Telegraph and Construction Company of the Agence Havas (Limited).

The statutory general meeting of this Company was held on Wednesday last at the Company's offices, 12, King William-street, E.C., Colonel W. J. Engledue (the Chairman) presiding.

The SECRETARY (Mr. Theodore J. Ford) having read the notice convening the meeting,

The CHAIRMAN said: Although the usual four months from the date of the registration of the Company has not elapsed, your Directors have thought it advisable to convene the statutory meeting in order to explain the position of the Company, and the difficulties which have arisen owing to the hesitation to fulfil their obligations on the part of a considerable proportion of those who undertook to subscribe the necessary capital. We proceeded to allotment on total applications for 12,177 shares, representing £60,885; but I regret that several subscribers have failed to pay, and in order to carry out the objects of the Company it has been necessary to take legal proceedings against some of the defaulters. This disappointing result prevented an immediate settlement with the vendors and promoters, and also prevented the acquisition by the Company of the patent, for which the vendors had agreed to pay the patentee £7,000 in cash and a proportion of their fully-paid shares, as the Directors could neither part with cash nor issue shares to the vendors, as their contract was not fulfilled. After six weeks' waiting for a settlement, the patentee reluctantly cancelled his agreement with the vendors and promoters. We then rescinded the original contract, and were able to acquire the patent from another source without payment of any cash. I understand the patentee had sold for shares only, showing his complete confidence in his invention. Mr. Wright, the patentee, has throughout acted with the greatest patience and consideration, and the new vendor has, I am told, arranged to make over a proportion of the fully-paid shares, issued to him, to such of those persons interested with the former vendors who are worthy of such consideration. He has also materially assisted the Directors by placing in trust £10,000 of his fully-paid shares to meet any deficiency in the subscription of the £40,000 working capital, should the Directors be unable to collect these liabilities from defaulting shareholders. It, therefore, only remains for the shareholders to pay the calls now due to enable the enterprise to proceed to a successful issue. The shareholders are aware that the Agence Havas holds the leading position in France as a news agency. For many years it has enjoyed the confidence of the leaders and representatives of every form of Government in France; it receives the earliest and most reliable political news, and is probably the only organisation of the sort to which the French Government would grant such concessions as have enabled the Company to be started. Rival agencies have attempted to obtain similar rights to enable them to introduce inferior printing telegraph machines into Paris, but have failed, the result being an undercurrent of intrigue, having for its object the wrecking of their undertaking. When the Company was registered, the Agence Havas had received many applications for the printing telegraph machines, and were canvassing for further support; but as complications arose which threatened to delay our progress indefinitely, it was necessary to desist from taking orders which it would be impossible to execute. There were 66 actual subscribers, who will pay a yearly rental of 105,700fr., making an average of 1,600fr. per subscriber. Amongst these clients are banks, clubs, and hotels. As all subscriptions are to be paid in advance, on the receipt of machines, we are, I think, commencing business on favourable terms. Bearing in mind the financial complications that have arisen, and pending the result of the legal proceedings against defaulters which your Directors have been reluctantly obliged to take, it has been thought advisable not to estimate for more than 125 machines at first. These will be arranged on ten circuits, which will be capable of accommodating more machines as necessity arises. These circuits have been very carefully worked out under the direction of M. Houssaye, our manager in Paris. Tenders are now being invited in Paris for the cable necessary for the circuits, and 125 machines are in course of manufacture in New York. If, after this meeting, the shareholders come forward at once and meet their obligations, the first installation of machines could be fixed within about four months from this date. If, however, there should be delay, the Directors will hesitate before accepting any tender or incurring expense. Delay will cause great uneasiness amongst those who have promised to take the instruments, and might prevent the Agence Havas from pushing the business. The Directors consider the prospects even better than those foreshadowed in the prospectus. I have no accounts or business to place before you at this meeting. Mr. C. Cammell, one of the original Directors, has resigned his seat, and Count Max Hollender has consented to consider if he can fill the vacancy.

Mr. EDWARD MOXON blamed the Board for going to allotment on too small a subscription.

Mr. MAY (the solicitor), in reply to a question, stated that the Company was in legal possession of the patent.

Count MAX HOLLENDER stated that he was not anxious to join the Board, and only proposed to do so because several of his friends were large shareholders.

The CHAIRMAN next read a letter from Mr. John Burke (one of the contractors), who "was unable to attend the meeting, but who had seen two of their machines at work in Paris. These were not of the latest pattern, one of them having been in use in Paris for nine months; but both seemed to run very smoothly, and were so simple that there was evidently nothing likely to go out of order. He felt decidedly encouraged by what he saw."

Mr. BEYFUS suggested that one vacancy on the Board be filled up by appointing Sir Augustus Harris.

In reply to Count Max Hollender, the CHAIRMAN stated that to lay down 125 machines, including the cable and other expenses, would cost the Company about £10,000, and it was proposed to call up £1 per share at once, and another £1 per share in two months' time.

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NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1893, pages 320-348, *&c., &c.*]

DAIMLER MOTOR SYNDICATE (LIMITED).—This Company was registered on May 26th, with a capital of £6,000, in £10 shares, to carry on the business of engineers, &c.

FORD-LLOYD MANUFACTURING COMPANY (LIMITED).—This Company was registered on June 7th, with a capital of £10,000, in £1 shares, to acquire and take over as a going concern the business of electrical engineers, and manufacturers of electrical appliances, carried on by the Ford Lloyd Manufacturing Company, at Mount Pleasant, Clerkenwell, London, E.C., and at Penarth Works, Bermondsey, S.E.; to acquire and sell the invention known as the "E.S. Dry Battery," and to carry on business as an Electric Light, Heat, and Power Supply, and Telegraph and Telephone Company. The subscribers are:—Arthur Ford-Lloyd, E. J. Tumber, C. H. Elliott, E. P. Grove, A. Grundy, W. M. Foxcroft, and E. A. Herbert. The first directors are:—E. J. Tumber, A. Ford-Lloyd, and C. H. Elliott, who are also managing directors, with a salary of £200 per annum each.

FOSTER BROTHERS (LIMITED).—Registered, with a capital of £30,000, in £10 shares, to acquire, as a going concern, the business of tube manufacturers and galvanisers, now carried on by H. Foster, J. F. Green, and J. Foster, and to carry on and extend the same.

"INDUSTRIES" AND "IRON" (LIMITED).—A Company was registered on May 24th, with a capital of £90, divided into 1,800 shares of 1s. each, to acquire the copyright and goodwill of the two journals known respectively as *Industries* and *Iron*, and with a view thereto to enter into an agreement with Mr. C. Arthur Pearson, of *Pearson's Weekly*, *Search-Light*, *Society News*, &c.

MERIONETHSHIRE ELECTRIC LIGHTING, POWER, AND APPLIANCE COMPANY (LIMITED).—This Company was registered on June 9th, with a capital of £3,000, in £1 shares, to adopt and ratify an agreement between A. Hall and Co. and F. H. Handy on behalf of the Company, and to establish and carry on at Dolgelly and elsewhere the business of supplying electricity for the purposes of lighting, heating and motive-power, and to carry on the business of electricians, mechanical and electrical engineers, and manufacturers of, and dealers in, all apparatus and things required for, or capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity. The subscribers are:—H. May, W. Williams, J. C. Roberts, F. Whiteley, H. W. Brethertion, A. Thorburn, F. H. Handy. The first Directors are:—J. C. Roberts, W. Williams, F. Whitely, A. Thorburn, Henry May, and Dr. Lloyd Williams, of Dolgelly.

PIONEER ELECTRIC CARRIAGE COMPANY (LIMITED).—This Company was registered on June 8th, with a capital of £20,000, in 400 shares of £50 each, to enter into an agreement to be made between the Electrical Power Storage Company (Limited) and the newly-formed Company, to acquire, develop, and turn to account letters patent, patent rights, inventions, and other privileges connected with the propulsion of vehicles and carriages on tramways, highways, and roads by means of electricity, to construct or otherwise acquire vehicles propelled by electricity or otherwise, to obtain licenses for the same under the Hackney Carriages Acts, and to let the same for hire, and carry passengers and goods. The subscribers are:—J. Irving Courtenay, F. King, J. W. Barclay, Sir. Geo. R. Prescott (Bart.), Major-General Chas. E. Webber, Sir Daniel Cooper (Bart.), and F. Green. The first Directors are to be nominated by the signatories.

RICHARD POORE AND CO. (LIMITED).—Capital £6,000, in £1 shares Objects: To carry on the business of electrical engineers, engineers, electricians, suppliers of electricity for the purpose of heat, light, motive-power, &c.

SIR WILLIAM ARROL AND CO. (LIMITED).—This Company has been formed to purchase the business of contractors and engineers carried on at Glasgow and elsewhere, with a capital of £150,000, in £10 shares.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).—The annual return of this Company, made up to October 14th last, has been filed. The nominal capital consists of 150,000 ordinary shares of £3 each, and a like number of preference shares of £2 each. 78,383 ordinary and 75,000 preference shares have been taken up, and the full amount called, resulting in the total payment of £385,149.

DISTRICT MESSENGER SERVICE AND NEWS COMPANY (LIMITED).—In consequence of the acquisition of the business of the Boy Messengers and Electric Call Company (Limited) this Company, on June 9th, increased its nominal capital from £200,000 to £275,000, in £1 shares, pursuant to a resolution passed April 24th.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 3rd, shows that 250,000 out of the 300,000 shares, of £10 each, have been taken up, the full amount called, and all calls (£2,500,000) paid.

ELECTRIC STORES (LIMITED).—The annual return of this Company, recently filed, shows that the seven original signatories are the only shareholders out of a nominal capital of £15,000, in £1 shares.

ELECTRIC TRAMWAYS CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—Although this Company was registered in 1886, with a capital of £250,000, in £1 shares, the last return, made up to May 8th, shows that the signatories' shares are the only ones taken up, no calls having been made.

ELECTRICAL WORKS CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—Mr. P. A. Latham, acting secretary of this Company, informs the Registrar of Joint-Stock Companies that the Company has never done any business, and that the seven members constituting the concern desire that the Company be struck off the register.

ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY (LIMITED). A petition was presented on the 2nd inst. for the winding up of this Company, and is down for hearing on Wednesday next, the 21st inst.

FOREIGN PILSEN ELECTRIC LIGHT AND POWER COMPANY (LIMITED). The annual return of this Company, made up to March 14th, shows that 29,800 shares out of a total capital of £30,000, have been taken up, and all have been issued as fully paid to the shareholders of the Union Electric Light and Power Company (Limited).

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY (LIMITED).—A meeting will be held at 5, Moorgate-street, E.C., on July 20th, at 2 p.m., to receive an account of the winding-up.

CITY NOTES, &c.

CALLS DUE.—*June 27:* EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED), 20 per cent. on £200,000 Four per Cent. (Mauritius Subsidy) Debentures of £25 each.——*June 30:* BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED), final £1 on 10,000 new ordinary £3 shares, and final 10s. on 15,000 new Six per Cent. Preference Shares of £2 each.; NATIONAL TELEPHONE COMPANY (LIMITED), 25 per cent. on £273,523 Four and a-Half per Cent. Debenture Stock.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended June 11th were £759, as against £745 for the corresponding period of last year, being an increase of £14. The total receipts for the half-year amount to £20,252, against £18,614 in the corresponding period of 1892, being an increase of £1,638.

COMMERCIAL CABLE COMPANY.—The Board announce a quarterly dividend of 1¾ per cent., payable on July 1st.

BIRMINGHAM MINT (LIMITED).—At the annual meeting, held at Birmingham on Thursday, a dividend of 7 per cent. was declared. The Chairman, in moving the adoption of the report, said the depression in trade had seriously impaired the profits, and the fall in price of spelter and copper made a loss of £1,400. The profitable branch of the business had been not minting, but seamless tubes and other special manufactures.

DAN RYLANDS (LIMITED).—The Directors of this Company regret to announce the resignation of Mr. Dan Rylands as a Director. Mr. George Herbert Peake, of the Strafford Collieries, Barnsley, has been elected to Mr. Rylands's seat on the Board. This resignation will not in any way affect the business of the Company, who are well known as makers of glass-lined tubing, electrical glass wire, &c.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).—The coupon on this Company's Five per Cent. Australian Government Subsidy Debentures, due on the 1st July prox., will be paid on and after that date by Messrs. Barclay, Bevan and Co., 54, Lombard-street, E.C. Coupons must be left three clear days for examination.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—Letters of allotment for the recent issue of £200,000 Four per Cent. (Mauritius subsidy) Debentures have been posted.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).—Notice is given by this Company that the transfer books and registry of members will be closed from the 13th to the 27th inst. for the purpose of preparing dividend warrants.

GENERAL ELECTRIC COMPANY (NEW YORK).—American advices notify extraordinarily heavy sales of general electric stock, for which friends of the Company are at a loss to account.

NATIONAL TELEPHONE COMPANY (LIMITED).—Sir Albert K. Rollit, M.P., has joined the Board of this Company.

SOCIETE GENERALE DES TELEPHONES.—An extraordinary general meeting of the shareholders was called for yesterday (Thursday) to consider a scheme of reconstruction, under which the Company would be wound up and a new Company formed with a reduced capital of 15 million francs. The old Company will only continue to exist for the purpose of carrying on its actions in the law courts against the Municipality of Paris, and against the Government. The shareholders are to receive, for each five shares they now possess, three of the new Company and five bonds in the liquidation, these latter representing the shares in the old Company in the distribution of the sums receivable from the Government and the Municipality.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee have ordered ordinary shares Nos. 1 to 15,000, and Six per Cent. Preference Shares Nos. 1 to 28,000, of the Monte Video Telephone Company (Limited) to be quoted in the official list,

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SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—The Directors have resolved to pay an interim dividend at the rate of 5 per cent. per annum in respect of the six months ended March 31, 1893, as follows: 1s. 9d. per share on the 78,949 ordinary shares of the Company (£3. 10s.), and 2s. 6d. per share on the 19,750 £5 fully-paid shares, free of income-tax. Warrants will be issued 20th inst.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended June 9, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,768.

WESTERN UNION TELEGRAPH COMPANY (LIMITED).—This Company have declared their usual quarterly dividend of 1¼ per cent.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price. June 7.	Price Wednesday, June 14.	Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business done during week ending June 14. Highest	Lowest.
			TELEGRAPHS						
£1,134,640	Stock	12 6	Anglo-American	49½ 50½	51½ 52½	5 1 9	Jan., Apr., July, Oct.	51⅝	..
£2,932,680	Stock	2/0	Do. Preferred	91½ 92½	94 95	5 15 9	" "	94½	92½
£2,932,680	Stock	5/0	Do. Deferred	11 11½	11½ 12	.. ..	" "	11⅝	11⅜
£195,100	100	4%	African Direct Telegraph 4% Deb. (Reg. & Bearer)	101 104	101 104	3 16 11	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	11⅜ 12½	11⅞ 12½	5 6 1	Mar., June, Oct., Dec	12½	11⅞
£26,400	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	10.4	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107 111	107 111	4 10 1	June and December	..	..
$7,716,000	$100	$1⅜	Commercial Cable Capital Stock	140 150	140 150	4 13 4	April and October..	145	..
16,000	10	8/0	Cuba Submarine	11½ 12½	11½ 12½	6 8 0	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	18½ 19½	18½ 19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½ 3½	2½ 3½	4 11 5	April and October..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅜ 11⅞	11⅜ 12	5 16 8	Jan., Apr., July, Oct	11⅞	11⅝
400,000	10	2/6	Eastern	15½ 15⅝	15½ 15⅝	4 4 6	" "	15⅝	15
70,000	10	6%	Do. 6 per Cent. Preference	16½ 17	16½ 17½	3 9 7	" "	17	16¾
£1,594,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112 115	112 115	3 9 7	May and November	113½	..
£105,900	100	5%	Do. 5 per Cent. Debenture, 1899	108 111	108 111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	15⅝ 15⅞	15⅝ 15⅞	4 8 2	Jan., Apr., July, Oct.	15⅞	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	112 115	112 115	3 9 7	February & August	114	..
£70,600	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	104 107	104 107	4 13 6	January and July ..	104¾	..
£103,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101 104	102 105	3 16 2	February & August	104	102½
180,227	10	2/3	Globe Telegraph and Trust	9⅝ 9⅞	9⅞ 10	4 10 0	Jan., Apr., July, Oct.	9⅞	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	15½ 15⅞	15⅝ 15⅞	3 15 7	" "	15⅝	15⅜
150,000	10	7.2	Great Northern	19⅜ 20	19⅜ 20	4 5 0	Jan., April, and July	19⅝	19½
£100,000	100	5%	Do. 5 per Ct. Debentures, 1883 issue	105 108	105 108	4 12 7	March & September	107	..
17,000	25	37/6	Indo-European	40 43	40 43	5 16 3	May and November	..	..
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	6 13 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	107 110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs.	101 104	101 104	3 16 11	.. ..	..	..
11,802	8	4/0	Reuter's	6½ 7½	6 7	..	April and October..	..	..
8,331	£100 Cert.	30 0	Submarine Cables Trust 6 per Cent.	119 124	120 125	4 16 0	" "	119½	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July ..	..	..
£360,000	100	5%	Do. 5 per Cent. Debentures	100 103	99 102	4 18 0	March & September	..	..
80,000	10	2/0	West Coast of America	3 4	3 4	.. ..	January and July ..	..	..
£150,000	100	8%	Do. 8 per Cent. Debenture, 1902	103 107	103 107	7 9 7	June and December	..	..
88,321	10	6d.	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	.. ..	.. ..	1⅜	1⅛
34,563	10	6%	Do. 6 per Cent. 1st Preference	11 11½	11¼ 11½	5 6 8	May and November	11	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9½ 10½	9½ 10¼	5 14 3	" "	10	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1907	108 111	108 111	4 10 1	June and December	..	..
64,242	15	4 6	Western and Brazilian	7½ 8	7¼ 7¾	4 13 11	May and November	7¾	..
33,129	7½	4 6	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	5 15 3	.. ..	6⅝	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1½ 2¼	1½ 2	.. ..	.. ..	..	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106 109	106 109	5 10 1	February & August	..	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106 109	106 109	5 10 1	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120 125	120 125	5 12 0	May and November	..	..
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	1½ 2½	1½ 2½	.. ..	.. ..	..	..
224,880	14/0	1½d.	Consolidated Telephone Const. & Maintenance	⅝ ⅞	⅝ ⅞	.. ..	May and November	—	—
220,000	£1	4½d.	Oriental (11s. paid)	½ ¾	½ ¾	7 18 2	Yearly	..	..
458,867	5	2/6	National	5⅛ 5⅜	5⅛ 5⅜	5 11 7	June and December	5⅜	5⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14½ 15½	14½ 15½	3 18 8	" "	15⅞	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14½ 14⅞	14½ 14⅞	4 1 4	" "	..	..
90,950	5	6¾d.	Do. 5% Non-Cumulative 3rd Pref. (£3 paid)	5⅛ 5⅜	5⅛ 5⅜	.. ..	.. ..	5⅜	5⅛
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	1 2 115	113 117	3 16 11	January and July ..	115	114½
58,000	5	1/0	United River Plate	2 3	2½ 3	.. ..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	11½ 12	11½ 12	—	—	11⅞	11½
20,000	10	..	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½ 13	12½ 13	..	..	12⅞	12⅝
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	—	—	—
£150,000	£5	..	Electricity Supply Company Ordinary	.. ..	.. ..	..	—	—	—
£50,000	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	—	—	—
8,322	£5	..	House to House Electric	.. ..	.. ..	..	—	—	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	.. ..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July ..	..	..
33,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	1¼ 1½	1⅛ 1⅜	..	..	..	..
10,000	£5	5/0 '92	Do. (fully paid)	6⅛ 6⅜	6⅛ 6⅜	..	..	..	..
111,000	5	..	London Electric Supply	.. 1	.. 1	..	..	..	..
49,200	£10	4/0	Metropolitan Electric Supply (fully paid)	6 6½	6 6½	3 1 6	..	..	..
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	101 104	102 105	4 15 3	June and December	104	..
6,452	£10	..	Notting Hill Electric	5 6	5 6	—	—	..	..
19,980	£5	9½%	St. James' and Pall Mall	7¼ 7¾	7¼ 7¾	..	—	7⅞	7⅝
20,000	£5	7%	Do. 7 per Cent. Preference	8 8½	8 8¼	4 2 4	—	..	..
50,000	5	2/0	Westminster Electric Supply (fully paid)	5½ 5⅞	5½ 5⅞	3 0 10	—	5⅞	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/6	Brush Electrical Engineering	3⅛ 3⅜	3 3⅛	..	—	3⅛	3⅛
75,000	2	6%	Do. 6 per Cent. Preference	2⅛ 2⅜	2 2⅛	5 6 8		2⅛	2⅛
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	108 110	107 109	4 2 7	March & September	109	107½
20,000	5	5/6	Crompton and Co., 7 per Cent. Cumulative Pref.	5½ 5⅞	5½ 5⅞	6 1 9	January and July —	5⅞	5½
12,189	5	..	Edison and Swan United	.. ..	.. ..	—	—	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	.. ..	..	—	..	..
49,900	10	12/0	Electric Construction	2 2½	2 2½	..	—	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜ ⅝	⅜ ⅝	..	—	2½	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	—	—	½	..
50,000	10	15/0	India Rubber, Gutta Percha & c., Works	22½ 23½	22½ 23½	5 6 4	February & August	23½	22½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	1 12 104	4 6 7	March & September	102½	..
11,834	£10	6/4	International Okonite Ordinary	2½ 3½	2½ 3½	..	..	..	..
11,834	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	5/0 6/0	5/0 6/0	..	..	..	..
78,949	5	4/2½	Swan United (£3. 10s. paid)	2½ 3	2½ 3	13 8 4	May and November	2⅞	2⅝
37,350	12	24/0	Telegraph Construction and Maintenance	31 33	33 35	5 3 0	March and July....	33	31½
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102 105	103 106	4 14 4	January and July .	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	—	—	—	—
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	—	—	—	—
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	¼%	City and South London Railway	37 39	37 39	2 17 8	May and November	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 788.—Vol. XXXI. FRIDAY, JUNE 23, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

The Joint Committee of both Houses of Parliament, appointed to consider the prohibitions and restrictions which the National Telephone Company seek to impose upon those who obtain statutory powers to use electricity, have been sitting during this week. The members of this Committee, who are well qualified to consider the important questions before them, have already shown by their questions that they take a practical view of the subject. If the traction companies succeed in putting their case as fully as the National Telephone Company has done, their claims will have every chance of being exhaustively considered. The evidence of the railway companies, though at first rather alarming, ought to be disposed of without difficulty. Nor should there be any obstacle to the protection of the interests of the gas and water companies. They are more seriously threatened, though they have only just become aware of it.

The article appearing in this issue containing Mr. Rimington's ideas as to the cause of luminosity in vacuum tubes possesses several interesting points, but we are still of opinion that in these discharges the distinction between the electrostatic and electromagnetic parts of the phenomena has not yet been at all clearly demonstrated by any experimenter. Probably this will not be accomplished till the behaviour of electrostatic lines of force is more studied. It is curious that while the science of magnetism has been developed mainly by paying attention to the behaviour of magnetic lines, it has been found more convenient to study electrical phenomena by considering the distribution and motion of quantities of electricity. It is quite as uncommon to find in books any reference to tubes of electrostatic induction as it is to find magnetic phenomena explained by means of magnetic charges. Prof. J. J. Thomson has in some recent Papers drawn attention to the importance of the study of these electrostatic lines, or Faraday tubes, as he calls them; and in his new book, entitled "Recent Researches in Electricity and Magnetism," he makes considerable use of Faraday tubes in explaining the phenomena of the passage of electricity through gases. Prof. Thomson's important work will probably, as one of its results, have the effect of directing study to this, as yet, little used method of investigating the subject.

We have received a pamphlet describing a new French mathematical journal, the first number of which is to appear with the new year. The speciality of this publication is that it is to consist of two portions, one of which is to contain the particulars of useful or interesting problems which have as yet *not* been solved, while the other will deal with the previously published problems, and give such solutions of them as the readers of the journal have been able to supply. Mathematical articles of the ordinary kind will not be published, as those which appear will all have a direct bearing on the problems printed in previous numbers. The journal will provide its readers with plenty of material on which to exercise their analytical talents. It will also afford a means of drawing public attention to a problem in the solution of which a reader may be particularly interested. This journal deserves a favourable reception, as it will have a distinct tendency to increase the usefulness of mathematical work. Like all other branches of science, mathematics has become too much specialised, and the new publication should correct this tendency by suggesting problems of more general interest. It should also enlarge the number of applications of methods, which might otherwise remain unknown except in the special parts of mathematics in which they have been discovered. It is to be hoped that the financial difficulties which must occur in supporting a magazine of this kind will be successfully overcome. As regards the printing, which is specially important in connection with mathematical journals, the promoters are to be congratulated on having secured the support of the firm of Gauthier-Villars et Fils of Paris, who will bring out the journal under the title of *L'Intermédiaire des Mathématiciens*.

Among the original communications appearing in the June number of the *Journal* of the Institution of Electrical Engineers is one entitled "Some Advantages of Connecting the Coils of Electromagnets in Multiple Arc." A perusal of this article shows, however, that the advantages in question are imaginary. The writer considers the case of two similar electromagnets, each with 1,000 turns of wire, arranged in series in one case, and, in the other, in two sets of 500 turns joined in parallel. He then shows that, if the magnets are excited by the same current, the number of ampere-turns is twice as great in the former case as in the latter, while the energy spent is no less than four times as much. But this is no advantage in favour of the magnet with parallel winding, for as the heating depends on the square of the current, when the magnets are excited to the same extent, the number of watts spent will be identical in the two cases. The writer appears to have quite

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overlooked this point. Even, however, if it were true that the energy required for magnetisation could be reduced by the method suggested, it would not show that the arrangement of the coils in parallel is advantageous; it would only prove that magnets should be wound with a few turns of thick wire rather than with many turns of thin.

It is further stated that winding the coils in parallel diminishes sparking and accelerates magnetisation. When the coils joined in parallel are of an unequal number of turns, the self-induced electromotive forces occuring on breaking circuit are unequal, and cause currents to circulate in the coils and to absorb the energy of the magnetised iron otherwise spent in producing sparks. In many cases, therefore, it has been found advantageous to wind magnetising coils in parallel. If, however, these coils are all alike, so that the number of turns on each is the same, nothing is gained by parallel winding that would not be more easily secured by the use of thicker wire. It is, moreover, not true that the rate of magnetisation or of demagnetisation is accelerated by parallel winding. The rate of growth of magnetism depends on the ratio of the self-induction of the circuit to the resistance, and parallel winding diminishes one of these quantities to exactly the same extent as the other.

Some interesting observations dealing with the subject of the dimensions of units have been communicated to recent issues of the *Comptes Rendus* by M. Abraham. His last note on this subject is of considerable value. It is an attempt to establish between the dimensions of absolute temperature, and the fundamental units of length, mass, and time, a connection which is independent of the properties of any physical substance. Previous attempts to arrive at the dimensions of temperature have met with but very slight success, and Prof. Rücker has proposed to provisionally accept temperature as a new fundamental unit, like magnetic permeability or specific inductive capacity. The line of argument pursued by M. Abraham in attacking this subject is original and ingenious. He starts with the fundamental law of electrolysis discovered by Faraday, that the number of ions liberated in a voltameter is dependent merely on the quantity of electricity which has passed through it, and is independent of the nature of the ion. There is a definite amount of electricity associated with a molecule of gas whether this gas be oxygen, or hydrogen, or any other, and M. Abraham proceeds to inquire whether there is any other property which, in a similar way, is common to all gases.

A relation of this kind is to be found in the simple connection which exists between the pressure, the absolute temperature, and the volume occupied by any given amount of any one of the permanent gases. This relation is that the product of the pressure and volume when divided by the absolute temperature yields a quotient pv/T which is invariable for the same quantity of the gas in question. M. Abraham accordingly points out that if a quantity Q of electricity is used to decompose *any* gas from an electrolyte and the value of pv/T be found for the gas decomposed the number which represents the quotient is proportional to Q under all circumstances, and is quite independent of the nature of the gas. This relation is a very remarkable one, whether we are, or are not, willing to admit the legitimacy of the next step which M. Abraham takes, namely, to equate Q to pv/T and to arrive at the dimensional equation $T = pv/Q$. If we admit the correctness of this procedure we must inevitably conclude that temperature is identical, dimensionally, with electrical potential. It is, however, not at all evident that the well-known law pv/T is a constant for the same quantity of gas, is sufficiently complete to justify the conclusion drawn from it. In the equation above, some other physical quantity may have had its dimensions "suppressed" just as those of magnetic permeability are even now often ignored in electrical equations.

In a Paper recently presented to the American Institute of Electrical Engineers, Lieut. Parkhurst suggests a few modifications in the construction and use of galvanometers of the d'Arsonval type. Of these, the only suggestion calling for any comment is the proposal to use a telescope and scale in place of the more usual arrangement of a ray of light focussed on to a scale by means of a concave mirror attached to the moving part of the instrument. There are, no doubt, great advantages in using the telescope method. Measurements can be made in this way with greater accuracy than is possible with the ordinary method; and they can, moreover, be performed without darkening the room in which the tests occur. On the other hand, concave mirrors are cheaper than plane ones, and a slight distortion of a concave mirror does not render it quite useless, whereas, unless the mirror employed with the telescope method is fairly large, and accurately plane, good results are impossible. The telescope method needs more expensive apparatus, and is far more tedious in practice. It is always used in laboratories when great accuracy is necessary, but under ordinary circumstances it is found more convenient and quite accurate enough to use a concave mirror. Many of the advantages which Lieut. Parkhurst speaks of can be secured by using a glow-lamp as a source of light, and focussing the filament on the screen by adjusting its distance from the concave mirror on the instrument. This method has been used with excellent results in many test rooms, as it is not really necessary to work in a darkened room, since the image of the filament is quite clearly visible in the ordinary dull light of a factory.

The Late Werner von Siemens.—The German Society of Engineers has issued a circular appealing for subscriptions for a proposed memorial to the late Werner von Siemens.

Cable Interruptions:—

	Dates of Interruption.
Paramaribo-Cayenne	April 15th.
St. Thome-Loanda	May 30th.

Ballarat.—The municipalities of Ballarat West and Ballarat East, dissatisfied with the present arrangements for lighting the public thoroughfares, are taking joint action with a view to the introduction of the electric light as the street illuminant. Mr. Murray, electrical engineer, of Melbourne, has been consulted on the matter.

Electric Traction at Halle.—At the recent meeting of the Halle Tramways Company it was announced that the Company had determined to introduce electric traction on their lines

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owing to the competition of the electric tramway recently opened, and owing to the fact that the public were exceedingly anxious that this step should be taken.

Electric Cranes for Wool Warehouses.—Until recently the Directors of the Union Warehouse Company, of Bradford, had made use of hydraulic power for working their cranes. They are now to be worked by electricity from the Corporation mains, the severe frosts of the past two or three winters having proved most destructive to the hydraulic plant.

The Electric Lighting of Barrack Yards.—At the barracks in the Mitcham-road four arc lamps have been fixed in the parade ground and one in the drill shed, with a view of obtaining the advantage of being able to practice battalion movements in the dark evenings without being confined to the small space afforded by the drill shed, which has hitherto been the only available space for the purpose.

Electric Cooking.—In a letter to the *Journal of Gas Lighting*, Mr. Thos. Fletcher says that he has no intention to be "down on" electric cooking, as there is no doubt it is simply an introduction to gas fuel. People will, he thinks, take up electric cooking first, and become educated in culinary cleanliness; then they will abandon electric cooking on account of its cost, and take up with gas, because their cleanly instincts will forbid a return to dirty coal fires. *Nous verrons!*

Electric Traction for Canal Work.—We referred in our issue of May 12th to a Bill passed by the New York State Legislature, making an appropriation for the purpose of experimenting with electric traction on the State canals. The Superintendent of Public Works has now issued an order directing that all who wish to submit devices for electric traction for boats must file their applications. Tests will be made, if possible, during the present season of navigation.

Engine Nomenclature.—In an article in *L'Electricien* dealing with that ever-burning question, the relative merits of high and low-speed engines, M. Simon points out that it is necessary to have a clear idea of what we really mean by a high-speed engine: do we mean one with a high piston speed, or one that runs at a high number of revolutions per minute? M. Simon is for denominating what are usually called high-speed engines "high-velocity engines," and restricting the term high-speed engine to one which has a high piston speed.

Melbourne.—The *Melbourne Age* states that the electric lighting station which is being erected for the City Council is fast approaching completion, and will shortly be ready for occupation. The whole of the plant has been landed in the colony, and the engines and boilers are now being placed in position. The whole of the poles for the overhead wires have been delivered, but they will be used until such time only as an underground scheme has been devised and carried out. It is confidently anticipated that everything will be in readiness to make the change from lighting by gas to electricity in about three months.

Copper.—According to Messrs. H. R. Merton and Co. the fresh copper supplies in England and France last month amounted to 7,941 tons, whilst the deliveries were 10,084 tons, the visible stocks in the two countries having been reduced from 52,094 tons at the end of April to 49,951 tons at the end of May; a smaller quantity than that recorded at any time since the collapse of the copper corner. Some difficulty is said to have arisen in inducing the American mine owners to consent to a prolongation of the restricted output arrangement, so that the rise in the price of copper may not continue. Bar copper rose from £43 to £44 per ton during May.

The Electrolysis of Water-Pipes.—A peculiar accident occurred a few days ago at the power-house of the West Side Railway Company, says the Milwaukee correspondent of the *Western Electrician*. The water main in front of the power-house burst, filling the street with water. The submerged tracks, and the impossibility of getting water for the boiler, made it necessary to abandon the whole line. The break occurred at 8 o'clock in the evening, and it was 10 o'clock before the water could be turned off. It is alleged that the accident was due to the corrosion of the pipe by electricity escaping from the cables. The cable ran parallel to the pipe, and close to it.

Boiler Explosions.—It is satisfactory to discover, from a recent report of the Board of Trade on this subject, that "the results of the working of the Boiler Explosions Acts do not tend to show that careless management of boilers is on the increase. Although the total number of cases of all kinds dealt with is higher than in past years, it must be remembered that every year the requirements of the law as regards reporting explosions are becoming more widely known, and that, although the number of boilers in use is probably becoming greater in each succeeding year, the actual loss of life and the number of grave cases dealt with show no tendency to increase."

Night Navigation of the Suez Canal.—Nearly 91 per cent. of the vessels using the Suez Canal in 1892 pursued their journey uninterruptedly at night by using the electric light, the percentage in the three preceding years being 88·21, 83·56, and 71·74 respectively. The Suez Canal authorities have made it obligatory that, after October 1st next, vessels passing through the canal by night shall employ an apparatus for dividing the light of the projector into two divergent rays. Approaching vessels may, by this means, travel right up to each other without their respective helmsmen being blinded. The diverging apparatus which is to be used has been devised by one of the agents of the Company.

Compass Disturbances.—We hear that the Admiralty has directed that all warships fitted with 300 and 400 ampere dynamos are to be specially swung for the purpose of ascertaining the effect of the dynamos on the ships' compasses. The effect on all the compasses is to be noted, and a report forwarded to the Admiralty. The Lords of the Admiralty have decided to enforce a minimum distance between dynamos and compasses, depending on the size of the dynamo. In the light of the experiments that are now to take place it would be interesting to know the distances between the dynamos and compasses of three of Her Majesty's ships that are said to have recently been damaged by getting into positions at direct variance with the navigator's intentions.

Lightning Fatalities.—From every part of England, as well as from many distant countries, comes intelligence of thunderstorms, and of havoc wrought by lightning, which has been of almost unparalleled severity. A number of deaths have resulted. At Fort Westmoreland, in Ireland, a soldier was struck by a flash, which tore all his clothing from his body, burned his boots, shattered the toes of his feet, charred one side of his body, and blackened his face beyond recognition. At Lampeter (South Wales) the lightning took the skin off the backs of a flock of sheep, burnt the wool, and then earthed. Near Devizes four burning farmhouses could be seen at one time. Simultaneously with this electrical activity, it is interesting to note the usual fall in atmospheric temperature.

American Telephone Patents.—The American Bell Telephone Company and E. Berliner have filed their answer to the Bill lodged by the Government to annul the Berliner patent in the United States Circuit Court for the District of Massachusetts. The answer is a general denial of all the charges made in the Government complaint, and avers that due diligence was observed in the prosecution of the case in the Patent Office; that the patent was ready for issue as early as 1882, and would then have been issued, but for the action of Examiner Brown, who rejected all its claims and raised other objections, all of which could have been done before that date. The Bell Company also aver that in the applications for the Berliner patent, all due forms of law were observed, and that the Government cannot repudiate the acts of its own agents established by the laws creating the Patent Office.

The Influence of Magnetisation on Thermo-electric Force. M. Chassagny has a note in a recent number of *Comptes Rendus* on the influence of longitudinal magnetisation on the electromotive force of an iron-copper thermo-electric junction. Two couples were used, one being in the axis of a long magnetising helix, so joined together that they acted in opposite directions. The results obtained were:—(1) The effect of longitudinal magnetisation is always to increase the electromotive force. (2). This increase is independent of the direction of magnetisation. (3) For increasing fields the increase is, at first, very nearly proportional to the strength of the field,

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and attains a maximum value of 6·1 microvolts for a field of 55 C.G.S. units. After this, it slowly decreases, till, for a field of 200 units, it is 3·2 microvolts.

Switzerland.—We are indebted to the *Schweizerische Bau-Zeitung* for the following interesting statistics relating to the increase of electrical work in Switzerland between the dates December 31, 1890, and December 31, 1892. The isolated plants and central stations had, at the end of last year, an aggregate output of 11,422 kilowatts, an increase of 64·5 per cent.; and the total plant capacity of all electrical installations has increased 34·7 per cent. Among the more notable features are four electric tramways, with overhead conductors; the use of 17 alternate-current motors, a distance of 8 kilometres from the station to furthest lamp, in the case of the Mabrack-Pfäffers-Ragaz alternate-current station; and a synchronous 100-H.P. motor at Chur; and two "drehstrom" transmissions at Spreitenbach and Bülach-Oerlikon, the former working at a pressure of 5,000 volts, over a line 17 kilometres long, the latter at 13,000 volts, over a line 19 kilometres long, the power transmitted being, respectively, about 900 and 450 H.P. The statistics, unfortunately, do not show to what extent waterfalls are used as a source of power.

Truth in Science.—In a letter to the *Engineer*, with regard to the ether, Dr. Oliver Lodge winds up a lengthy controversy that has been raging in the columns of our contemporary with the following remarks:—

All scientific men must agree that freedom of discussion and absence of dogmatism are the life-blood of science. There is a distinction to be drawn, however, between dogmatism and instruction. Before there can be rational discussion on any subject, the facts should be equally known by both sides; and, until this state of things is reached, instruction is more appropriate than discussion. It is, perhaps, difficult sometimes to know where one should end and the other begin. Most certainly the theory of light is not complete; and as to the theory of ether, it is hardly begun. The same may be said for the theory of matter, and for the theory of gravitation. But we do not therefore call "matter" a hypothesis, or doubt the fact of its gravitative attraction. Whatever be hereafter discovered about the cause of gravitation, the Newtonian laws of its action cannot be upset; they are true, though of course not the whole truth. So also with the wave theory of light; so far as it goes, it is true, and not likely to be upset by any discoveries of the future. The ultimate mechanism of light is, indeed, still unknown; the complete theory of light has yet to be made, but nevertheless it certainly consists of transverse waves in a medium; and the frequency and length of these waves are known with as great accuracy as the frequency of a tuning-fork and the length of a metre—I am not making random statements—and the complex facts of optics are explicable on the wave theory just as the facts of astronomy are explicable on the gravitation theory; but to call either the complete theory, or to pretend that any assertion yet made by man is the whole truth about anything, however apparently simple, that would be a procedure less than sane.

The Specific Heat of Carbon.—In a note in the *Comptes Rendus* for May 8th, M. Le Chatelier remarks that it may not be without interest, in connection with the recent experiments of MM. Moissan and Gautier on boron, to recall the fact that the specific heat of carbon can no more than that of boron be made to agree with the law of Dulong and Petit. Monckman has already pointed out that Weber's experiments do not, in connection with the variation of the specific heat of carbon, lead to a law tending asymptotically to a fixed value, as is usually asserted. On the contrary, these experiments indicate a continuous increase above 250°C. At 250°C. the law of variation undergoes a sudden change, and the same discontinuity is observable at this temperature in regard to all the other properties of carbon: electric conductivity, expansion, thermo-electric power. Recent experiments carried out by MM. Euchène and Biju-Duval, engineers to Paris Gas Company, place Monckman's interpretation beyond doubt. The numerous experiments of these engineers show, moreover, that the specific heat of graphite (retort carbon) increases from 250°C. to 1,000°C. in rigorous proportion to the temperature, and that the rate of increase is much higher than would seem to result from Weber's experiments. The atomic specific heat is given by the formulæ—

$$250° - 1{,}000° \quad . \quad . \quad . \quad . \quad c = 3{\cdot}54 + 0{\cdot}0246t.$$
$$0° - 250° \quad . \quad . \quad . \quad . \quad c = 1{\cdot}92 + 0{\cdot}0077t.$$

Street Telegraph Lines in Sydney.—Our Australian cousins follow in the steps of the Americans, even in the matter of street telegraph poles, but, unlike the Americans, the Australians do not appear to accept them as inevitable:—"The utter disregard usually borne by the powers that be to the architectural embellishment of cities under their governance," says the *Building and Engineering Journal*, "is strikingly shown in the suit of the Attorney-General *v.* E. Way and Co., of Sydney, instituted with a view to obtaining an injunction to restrain the defendants from permitting a verandah and parapet in front of their premises, in Pitt-street, to remain erected in such a manner as to interfere with the erection of telegraph wires along the street." The building in question, says our contemporary, was one of the most recent improvements to the streets architecture of Sydney. The awning and balcony were supported by pillars 19ft. high placed on the outer edge of the footpath, and a parapet about 2ft. high had been erected on the top, making the height from the ground about 21ft. It was complained that this parapet encroached upon the space occupied by certain telegraph wires. Our contemporary concludes by remarking, that "to the architects who are filled with laudable aspirations to create elegant forms and beauty-spots in Sydney, or ornament their structures, this decision comes as a strong warning not to depart from the stereotyped manner of doing as their fore fathers have done, which will, no doubt, bear meet fruit."

Glasgow Philosophical Society.—At the concluding meeting of the Session of the Glasgow Philosophical Society last week, Dr. J. T. Bottomley made three communications on subjects of public interest. Dr. Bottomley's first communication was on "Vacuum Tubes without Electrodes." In 1881 Dr. Bottomley showed to the Philosophical Society for the first time vacuum tubes which he had just then constructed, and which had no electrodes of any kind—that is, no conducting wires by means of which electricity can pass in or out through the non-conducting glass walls of the tube. On the present occasion all the phenomena of striation and of attraction and repulsion of the discharge by currents outside the tubes were shown within these tubes, in spite of the fact that the electrodes did not exist. Tubes containing pieces of Iceland spar was also exhibited, the crystals being illuminated by the molecular bombardment of the minute traces of gases still existing in the vacuum. It was shown that the phenomena are highly complicated with the mixed effects of current induction and of electrostatic induction; and that the electrostatic disturbance of the vacuum has not been sufficiently taken into account in attempts to explain the phenomena. The second Paper Dr. Bottomley contributed was on "Some Results of Instantaneous Photography," in the course of which he showed and explained many interesting photographs of flying bullets, for which he was indebted to Prof. Boys. Dr. Bottomley, in his third communication, exhibited and described a portable apparatus for "Testing the Insulation of Electric Light Wires." He explained that this matter was of great interest and of special importance, now that the electric light was being introduced into Glasgow for lighting streets and dwelling-houses. The instruments hitherto designed and offered for testing the insulation of houses and mains had been found by Dr. Bottomley to be very unsatisfactory, defective and costly, and he exhibited an improved apparatus for this purpose. He advocated very strongly the use of a very sensitive high-resistance galvanometer with proportional graduation, and a direct comparison between the insulation of the installation to be tested with high resistances prepared for the purpose. The galvanometer shown was a modification of Lord Kelvin's well-known tangent galvanometer used in his graded galvanometers. It was of such sensibility as to give a deflection of one scale division per millionth of an ampere, the magnitude of the division being such that one-tenth of a division was easily readable. The resistance of the galvanometer was 22,000 ohms. While testing with an electromotive force of 100 volts it was easy to exactly determine any insulation up to 150 megohms. The insulation expected in ordinary buildings might be from 10 megohms down to 200,000 ohms, according to the number of lights installed. Dr. Bottomley also exhibited resistances of a megohm (one million ohms) down to 100,000 ohms, and a portable bichromate battery constructed of minute test-tubes carefully insulated in paraffin, with small carbon rods and zinc wire.

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ALTERNATE-CURRENT TRANSFORMERS.*

BY W. E. SUMPNER, D.SC.

An alternating current traversing a coil provided with an iron core has to overcome the back electromotive force caused by the changing induction in the iron. When the magnetic circuit is good, the back voltage due to the core becomes, with ordinary frequencies, so nearly equal to the forward voltage applied to the coil that the resulting current is generally less than one-twentieth, and may even be less than one-thousandth part, of the current obtained by dividing the impressed voltage by the resistance of the coil. The voltage needed for overcoming the mere resistance of the coil is negligibly small compared with that needed to balance the self-induced electromotive force due to the changing magnetism in the core, and it thus happens that the electromotive force generated in *any* turn of wire surrounding the core depends on the number of turns of the primary coil and the voltage applied to it, but does not depend to any appreciable extent on the resistance of the primary or on the current flowing through it. A secondary coil wound with a suitable number of turns is capable of supplying a variable current at a very approximately constant potential, provided the voltage at the terminals of the primary be maintained constant.

In designing a transformer the following objects have to be kept in view :—The losses in the transformer should be reduced to a minimum, and especially those occurring on open circuit. The regulation should be good, *i.e.*, when the primary coil is supplied at a constant potential the drop of volts on the secondary, as the load is increased, must be small. The current on open circuit should be small to reduce waste in the leads. The construction should be cheap and durable, and the coils and core so arranged that the transformer may be easily taken to pieces for repairs. The weight should be as small as possible, consistent with the provision of enough radiating surface to keep the transformer cool.

Magnetic Circuit.

All the early transformers were of the *open circuit* type, the lines of force produced by the currents in the coils circulating partly through an iron core and partly through air; but it has since become the all but universal practice to make *closed circuit* transformers, the path of the lines of force being entirely through iron. In all cases the iron core must be well laminated in the direction of the lines of force to reduce loss of energy in eddy currents.

Losses due to Hysteresis.

If the magnetism of a piece of iron is changed in any regular way, a definite amount of energy is absorbed by it each time the change occurs This loss is said to be due to hysteresis, and our knowledge of its amount is mainly due to the researches of Prof. Ewing. It has been shown by Mr. C. P. Steinmitz that Ewing's results may be summarised in the following law :—

$$h = \eta \, \mathbf{B}^{1.6},$$

where h is the loss of energy in ergs in every cubic centimetre of iron for every double reversal of magnetism, the maximum induction density being $\mathbf{B}$ lines of force in C.G.S. units per square centimetre. η is a coefficient, the value of which depends on the quality of the iron. Ewing's results for very soft iron correspond with the value $\eta = 0{\cdot}002$. The value of η seems to depend much less upon the chemical constitution of the iron sample than upon its physical condition. Annealing decreases and hardening increases the hysteresis very considerably. The purer the iron the lower the value of η.

There is good experimental evidence† to show that the loss in hysteresis in any magnetic cycle does not depend upon the speed with which the magnetic changes take place, even if the frequency varies from 1 ∿ (period per second) to 150 ∿ (150 periods per second). Messrs. Evershed and Vignoles find that when tests are made *very slowly* the influence of magnetic lag is to diminish the hysteresis, sometimes by as much as 20 per cent. The value of η found by slow methods may thus have to be increased to this extent to render it applicable to transformers. This difference is, however, smaller than that often found between various samples of iron of the same manufacture. The value of η for the iron usually employed in transformers cannot be taken lower than 0·0025; a greater value is more probable, as the handling of the iron during manufacture hardens it and increases η For this reason it is advisable to carefully anneal the core-plates after punching.

If W_h is the loss of power in watts occurring in the core of a transformer due to hysteresis

$$W_h = \eta \, n \, \mathbf{B}^{1.6} \, U \times 10^{-7},$$

where U is the volume of the iron in cubic centimetres, $\mathbf{B}$ is the maximum induction density in C.G.S. lines per square centimetre, η is Steinmetz's coefficient, and n is the frequency of the current.

Losses due to Eddy Currents.

If v be the number of volts (mean) induced in any single turn of wire enclosing the magnetic circuit

$$v = 4{\cdot}45 \, S \, \mathbf{B} n \, 10^{-8},$$

where S is the area in square centimetres of the section of the magnetic circuit; also

$$V_1 = n_1 \, v, \qquad V_2 = n_2, \, v,$$

where n_1 and n_2 are respectively the number of primary and secondary windings, and V_1 and V_2 are the primary and secondary voltages.

If the core consists of m iron wires of circular section, the specific resistance of the iron being ρ, and the length of the magnetic circuit l centimetres, the number of watts W_e, lost in eddy currents is

$$W_e = \frac{v^2 \, l}{25 \, m \, \rho}.$$

Usually the core consists of a large number of thin plates of rectangular section. If there are m of these plates in the core, and if the section of each plate is m' times as long as it is thick

$$W_e = \frac{v^2 \, l}{a \, m \, m' \, \rho},$$

where a is a number which varies between 10 and 30, according to the value of m'. In ordinary transformers m' is very large, and $a = 12$ is the most probable number. The value of ρ for transformer plates may be taken as 13×10^{-6} at ordinary temperatures (Evershed). It increases by nearly half per cent. for every degree centigrade.

If t is the thickness of the core plates, in millimetres, $m \, m' \, t^2 \, 10^{-2} = S$, the section of the iron of the core (in square centimetres) we get by substitution and reduction

$$W_e = 64 \frac{v^2 \, t^2 \, l}{S} = l \, S \left(\frac{8 \, v \, t}{S} \right)^2.$$

The number of watts wasted in each cubic centimetre of the core by eddy currents thus equals

$$\left(\frac{8 \, v \, t}{S} \right)^2,$$

a quantity for which Dr. Fleming has given the formula $[n \, t \, \mathbf{B} \, 10^{-8}]^2$, where t is the thickness of the plates in English *mils*.

The thickness t should not exceed 0·5 mm., and the general practice is to use plates slightly thinner. If t exceeds half a millimetre, it has been shown by Profs. J. J. Thomson and Ewing that the eddy currents disturb the distribution of the lines of force in the core, that the losses caused by hysteresis are greater than the formulæ given above imply, and that the eddy current losses become excessive. With the values of t usually found in transformers, this disturbance is inappreciable. In order to avoid eddy currents flowing from one plate to the next, it is usual to insulate adjacent plates by means of a coat of shellac, or the interposition of thin varnished paper.

* All rights reserved. A contribution by Dr. Sumpner to a forthcoming work by Messrs. Geipel and Kilgour (*The Electrician* Printing and Publishing Company).

† See Dr. J. Hopkinson and Mr. B. Hopkinson, *The Electrician*, September 9, 1892; also Messrs. Evershed and Vignoles, *The Electrician*, September 30, 1892.

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This freedom from eddy currents is sometimes attained by the oxidation of the surface of the plates resulting from a special steaming process.

Losses in Resistance.

The average value in amperes of the current (in the primary of n_1 turns) needed to magnetise the core to a maximum induction $\mathbf{B}$ is very approximately

$$A_m = \frac{l \mathbf{B}^{\frac{1}{3}}}{10\, n_1},$$

where l is the mean length of the (closed) magnetic circuit (in centimetres). This formula follows from Dr. Fleming's formula for permeability,

$$\mu = 5{\cdot}6\, \mathbf{B}^{\frac{2}{3}},$$

which is reliable for values of $\mathbf{B}$ lying between 1,000 and 6,000. Formerly transformers were frequently worked with a higher value of $\mathbf{B}$ than 6,000, but general practice now favours much lower values. The actual open circuit current will be greater than A_m, owing to the loss of energy in the core, the increase of current is

$$\frac{W_h + W_e}{V_1}.$$

If W be the load in watts taken from the secondary coil at voltage V_2, the secondary current is $A_2 = W/V_2$, and the primary current at this load is

$$\sqrt{A_1^2 + A_m^2}, \text{ where } A_1 V_1 = W + W_h + W_e$$

The loss of power in the coils at this load is

$$W_c = (A_1^2 + A_m^2) r_1 + A_2^2 r_2,$$

where r_1 and r_2 are the resistances of the primary and secondary coils. This loss is expressed as a fall of voltage at the secondary terminals. The drop of voltage bears the same ratio to the voltage V_2 on open circuit that W_c bears to W. This ratio for good regulation should not exceed 2 per cent., and should be equally divided between the two coils of the transformer. Equality between the copper losses in the two coils can be secured by choosing such gauges in winding that the weight of copper in the primary coil is practically equal to that in the secondary. The insulation of the coils increases the space they occupy by fully 50 per cent. for the primary (thin) coil, and by about 10 per cent. for the secondary. To avoid eddy currents in the copper it is advisable to strand the secondary, but the use of strip or square section solid conductors is common. If the secondary consists of two coils put in parallel, the two conductors should be wound on together. The current density in the coils at full load varies with different makers of transformers. It frequently lies between 700 and 1,000 amperes per square inch.

Efficiency.

The efficiency of a transformer expressed as a percentage is

$$100 \left\{ 1 - \frac{W_h + W_e + W_c}{W + W_h + W_e + W_c} \right\}.$$

The weight of experimental evidence confirms the theoretical conclusion that the core losses, $W_h + W_e$, are constant under all conditions of load. It follows from this and from the facts that W_c varies as the square of the current, and W as its first power, that the efficiency of any transformer will be greatest when the load is such that

$$W_c = W_h + W_e,$$

or when the iron losses equal the copper losses. But this consideration alone does not determine the best load. To keep the transformer cool, a radiating surface of from 3 to 4 square inches per watt is required. A transformer in practice is often run for a great part of its time on a light load, and to secure the highest average efficiency the iron losses should be diminished at the exense of those occurring in the copper. To secure good regulation, the ratio of W_c to W should not exceed 2 per cent.; and with small transformers, which cannot be made as efficient as large ones, this consideration is the chief one needing attention.

LUMINOSITY IN VACUUM TUBES.

BY E. C. RIMINGTON.

The remarks made in the Editorial Notes of May 5, 1893, on my Paper before the Physical Society, on "Luminous Discharges in Electrodeless Vacuum Tubes," lead me to think that a short article on the subject of the cause of luminosity in vacuum tubes would be of general interest.

Take first the case of a uniform electric field between two flat plates (A and B, Fig. 1), to fix our ideas definitely. Introduce into this a cylinder of dielectric *a*, *b*. If this cylinder be composed of a dielectric of the same specific inductive capacity as that between the plates (presumably air), it will make no difference in the distribution of the lines of induction, if however, its specific inductive capacity be greater than air, as it would be if the cylinder were glass, ebonite, paraffin wax, or gutta-percha; for example, the effect of introducing it into the field will be to make the lines of induction crowd into it and pass through it; but it will produce no other effect. Suppose, now, this cylinder to become ever so slightly conducting, the lines inside it will collapse, their rate of collapse depending on the conductivity of the cylinder, and finally we shall have some of the lines starting from A, terminating at *a*, an equal number starting from *b* and terminating on B. On putting it in the ordinary artificial language of the text-book, *a b* will be electrified by induction, and there will be a negative charge at *a* and an equal positive charge at *b*. During the time taken for the first state to change to the second, there will be a current in the cylinder from *a* to *b*. If the cylinder were a good conductor the time taken for this change would be infinitesimally small, as the electric stress which exists in the cylinder when it is a dielectric and non-conductor, breaks down almost instantaneously in the case of a conductor.

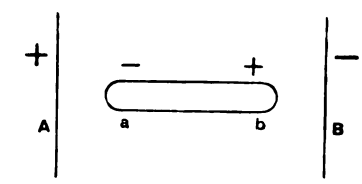

FIG. 1.

If the electric field between the plates A and B be made to vanish by connecting them together through a conductor, the lines terminating on and emerging from the cylinder will again pass momentarily through it, or in the artificial (but convenient) mode of expressing what happens, the + charge at *b* will reunite with the − charge at *a*, and there will thus be a current in the cylinder from *b* to *a*. Instead of discharging A and B, the cylinder may be removed out of the field, and practically the result will be the same. As regards the current in the cylinder (supposing it a conductor) its strength will depend on the rate at which the cylinder is put into or taken out of the field; the quantity of electricity passing will, however, be the same, whatever the rate. The energy dissipated by the cylinder will be greater the greater the maximum value of the current, that is, the greater the rate at which the cylinder is put into or taken out of the field, or if the cylinder is stationary, the greater the rate at which the field changes.

Let us now consider how a glass tube containing a rarefied gas will act when placed in the electric field. Air or any other gas acts as a dielectric, and is capable of having an electric stress set up in it; when, however, this stress exceeds a certain value, depending on the rarefaction of the gas, the gas gives way and becomes for the moment practically a conductor, allowing the lines of induction through it to collapse. This takes place even at ordinary atmospheric pressure when the electric stress is great enough, it is commonly known under the name of "brush discharge." It is best shown by an experiment described by Mr. J. E. Taylor in the *Electrical Review*, July 31, 1891; two clean and dry glass plates have a piece of tinfoil pasted on one side. They are then placed parallel to one another with their uncoated sides nearest each other and separated by an air space of about $\frac{1}{4}$ of an inch On connecting the tinfoil plates to the poles of a Wimshurst machine and

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looking between the plates, the break-down of the strain in the inner air space can be plainly seen in the form of sparks and brush discharges.

When it is said that the air or gas becomes practically a conductor, it must be understood that it does not conduct in the same manner as a piece of metal, but rather convectively, much after the manner of an electrolyte or of a lot of pith balls placed between two charged plates, the dissociated atoms * present playing the part of the pith balls.

To return to the exhausted tube; suppose it placed between the plates A and B, as in Fig. 1. The lines of induction pass through it, and if the electric stress be sufficient the rarefied gas will give way and the tube behave as if it were the conducting cylinder previously considered. While the lines passing through the tube are collapsing there will be a convection current flowing in the tube. During this collapse of the lines the molecules of gas in the tube will be in a state of more rapid vibration than corresponds to the temperature, and their collisions with each other will consequently be more violent; this will cause their own vibrations † to have more "overtones," as we may express it, by analogy with a sounding body. If these overtones be sufficiently developed we shall have the molecules capable of imparting to the ether surrounding them waves short enough to affect the retina of the eye, or the tube will appear luminous. To obtain luminosity it is necessary that the tube should be suddenly placed in, or withdrawn from, the electric field, so that the collapse of the electric stress may be sudden, as if it be at all gradual the increase in the vibrations of the molecules is not sufficient. This effect may be simply shown by holding a rubbed ebonite or glass rod close to an exhausted tube, and suddenly jerking it away; at the instant of doing this, a flash will be seen in the tube. The same thing will happen if the rod be suddenly brought up to the tube. Another way is to take a tube and place it flat on a silk or flannel rubber laid on the table, rub the tube on the silk, taking care that the whole of it is in contact with the latter, no luminosity will be visible; but, if the tube be suddenly lifted, there will be a luminous flash in it.

In the case of an ordinary Geissler tube, with electrodes attached to a battery of several hundred cells, there is an electric field set up in the tube between the electrodes, the rarefied gas gives way under the stress, producing luminosity; but the stress is immediately renewed by the battery, to again give way, and so on continuously as long as the battery is applied to the tube.

It is necessary, then, to produce luminosity in a vacuum tube of any sort that it shall be in an electric field (or have an electric field through it), which shall vary relatively to the tube; and, moreover, this variation must be sufficiently rapid. This can be done by placing the tube between two plates, which are alternately charged and discharged, or by jerking the tube rapidly into or out of the space between the plates, the charges on the latter being kept constant. (I have never succeeded in obtaining luminosity in this manner with plates, as I have been unable to jerk the tube quickly enough; but by jerking the tube away from the charged rod, previously described, luminosity is easily obtained.) Another way is to spin the tube about an axis at right angles to its length, between two charged plates, or near a charged ebonite rod, as described in a Paper on "Experiments in Electric and Magnetic Fields," by the author and Mr. Wythe Smith, and also in an article in this paper, March 24, 1893, entitled "A Novel Electroscope."

* The word atom is here employed in the chemical sense, as there seems to be a balance of evidence in favour of the fact that the molecules of a gas are incapable of receiving or giving up electric charges. In the case of an exhausted tube there will always exist a certain number of free atoms due to dissociation of some of the molecules; the number of these dissociated atoms appears to be increased on passing a discharge through the tube. This increase is sub-permanent. One proof of this is that if a freshly exhausted tube be taken it is insensitive, as far as luminous effects are concerned, to change in electric stress that is not above a certain value, as, for example, spinning it near a charged body; if, then, it is made to experience considerable change of electric stress as by allowing a Wimshurst machine to spark on to it, it will be found to be sensitive to the smaller change of stress which was previously too small to effect it. After being put aside for some months it again becomes insensitive.

† More probably the surgings of the charges of the atoms composing them.

Again, another method of producing electric stress in an exhausted tube or bulb is by having lines of magnetic induction passing through the bulb and rapidly varying their number and direction. This will give rise to closed circuits of electric stress within the bulb in planes normal to the direction of the magnetic induction. This effect is obtained by holding an exhausted tube close to a wire through which a Leyden jar is discharged, or by surrounding the tube with this wire. The electric stress in the tube will be greatest close to the wire, where the magnetic induction is strongest, and the breakdown of the gas will be most violent where the electric stress is the strongest, so that there will be a brilliant luminosity close to the wire. The rest of the closed path of the electric stress will be a more diffused and much feebler luminosity, which easily passes unnoticed by a casual observer, being swamped by the much brighter luminosity close to the wire. Fig. 2 shows practically what takes place. A B is the wire through which the Leyden jar is discharged, C E D the brilliant luminosity close to the wire, while the dotted lines C F D show the diffused luminosity forming the closed path.

It must be clearly borne in mind that these electromagnetic discharges, as they may be termed, are just as much produced by electrotatic stress acting in the rarefied gas, and under which it gives way, as in the case of a vacuum tube placed in a varying electric field, before considered. There is this difference, however, but it is quite a minor one, that in the former case the lines of electric stress are closed curves within the tube; in the latter they are not closed within the tube. It is simply in the cause of this electric stress that the two differ from one another, in one the electric stress being caused by bringing the tube into an electric field existing between or near to charged conductors; in the other it is caused by the varying of magnetic induction. In the case of a bulb surrounded by a

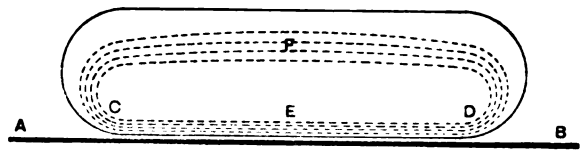

FIG. 2.

coil of one or more turns of wire connected to the outer coatings of two Leyden jars, there will be electric stress in the bulb due to the two causes, the one being due to the potential difference between different parts of the wire, and the other to the alternating current in the wire. Needless to say, these two stresses do not act in the same direction through the bulb; the first will act more or less from side to side, and if acting by itself would produce a faint luminosity filling the whole bulb; the second acts in a closed path following the wire, and produces a closed luminous band. The effect of the first may be much increased by connecting a conductor near to, or in contact with, some part of the bulb, to one of the outer coatings of the Leyden jars. I cannot agree with the remark made in the Editorial Note above referred to, that "where these two effects are mixed it is very difficult to follow the actions." I venture to think that the series of experiments described in my Paper before the Physical Society on "Luminous Discharges in Electrodeless Vacuum Tubes" pretty clearly shows the part played by the two effects in producing luminosity, and to that Paper (*Phil. Mag.*, June, 1893) I would refer the reader, who may desire fuller information on this subject. I may remark that all the experiments given in the first part of that Paper must be considered together, and as only one or two are given in the abstract of it published in *The Electrician* of May 5th, the argument cannot be followed from it.

An Electric Welding Car.—A special electric welding car has been constructed at Philadelphia for welding the rails of street railways in position. The car is provided with an electric welding plant, so constructed that current is taken from the trolley wire and transformed into a low-tension current of desired strength. The time taken is from four to sixteen minutes for a complete weld.

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INSTRUMENT FOR TESTING PRIMARY BATTERIES.

An instrument, which should prove of great service for testing the condition of a primary cell, has been designed by Major Holden, and was exhibited at a *conversazione* of the Royal Society. A small wooden case measuring 3½in. by 4½in. by 2in. deep, contains a dead beat voltmeter reading from 0·5 to 1·5 volt, and a resistance coil. The instrument, which is made by Mr. Pitkin, is shown in Fig. 1 with the outer case removed. The voltmeter *a* is constructed on the principle common to other Holden instruments, and briefly described in *The Electrician*, Vol. XXIX., p. 589. A club-footed magnet, or a horseshoe magnet, having one coil is used. The limb within the coil is circular, the outer one being flat, lying against the coil, the end projecting a little. The circular limb carries a small radial pole-piece. A jewelled arbor is mounted as an extension of the axis of the coil, and carries a soft iron radial needle; the end is tipped with brass to prevent magnetic contact. The action of the peculiar magnetic arrangement causes the iron needle to be repelled from the radial pole-piece when a feeble current passes, but when it has moved through an angle of some 10deg. the other pole of the magnetic system begins to attract it. As a result, a fairly uniform scale is obtained. A spring control is employed, which allows the instrument to be held in the hand and used in any position. A resistance coil, *b*, is provided, and a push-button, not shown in the illustration, acting on the spring-contacts *c*, reduces the resistance from 8 ohms to 2 ohms.

The method of using the instrument is as follows:—Two short, thick wires having been connected to the terminals terminating in ends or in a suitable double pointed spear, the ends or spear are put in contact with the poles of the cell it is desired to test; this gives one reading, viz., the difference of potential at the terminals of the cell when it is working through an external resistance of eight ohms (neglecting the resistance of the leads). Then by pressing the push in the side of the case another reading is obtained, this latter being the difference of potential at the terminals when the cell is working through two ohms external resistance; from these two readings (which should be taken as quickly as possible) the electromotive force and internal resistance can be calculated, or their values can be got by reference to a table. The following are the results of a few tests with well-known cells:—

	First reading.	Second reading.	E.M.F.	I.R.
1. Leclanché 6-block agglomerate round pattern (condition, very old)	1·32	1·22	1·35	0·22
2. Leclanché's porous pot pattern, 3-pint size (condition, new)	1·4	1·21	1·47	0·42
3. E. C. C. dry cell, special firing pattern, weight 6·25lb. (condition, new) ...	1·43	1·38	1·96	0·15
4. Leclanché Barbier dry cell, No. 1 size (condition, fair)	1·3	1·05	1·43	0·68

The methods of ascertaining the electromotive force and internal resistance of a battery are well known, and possibly the following graphical construction is not new, but it is well worthy of attention, being a singularly neat example of graphical calculation. On a piece of squared paper a scale from 0 to 8 is laid down from right to left, and on this is set off the external resistances of the instrument. On the same line, and with the same values of scale divisions, the internal resistance of the battery is to be measured. A vertical scale is chosen to give convenient angles in the construction of the diagram, and on it is set off the volts measured by the instrument. Straight lines are drawn from the 8 and from the 2 on scale of resistances through the readings on the vertical scale, and meet at a point on the right-hand side of the zero resistance. The horizontal distance of this point from the zero line gives the internal resistance. The height of this point measured on the vertical scale gives the true electromotive force of the battery. Figs. 2 and 3 relate to the second and third examples already given.

The possible element of error in such a method of testing as that upon which this instrument is based is, of course, that, owing to polarisation, the volts of the cell when circuited through the two ohms may be lower than its previous value when circuited through eight ohms, and that both of them will be lower than the volts on open circuit. The error is reduced to a negligible quantity by making the test quickly, and by preventing very large currents from passing through the cell;

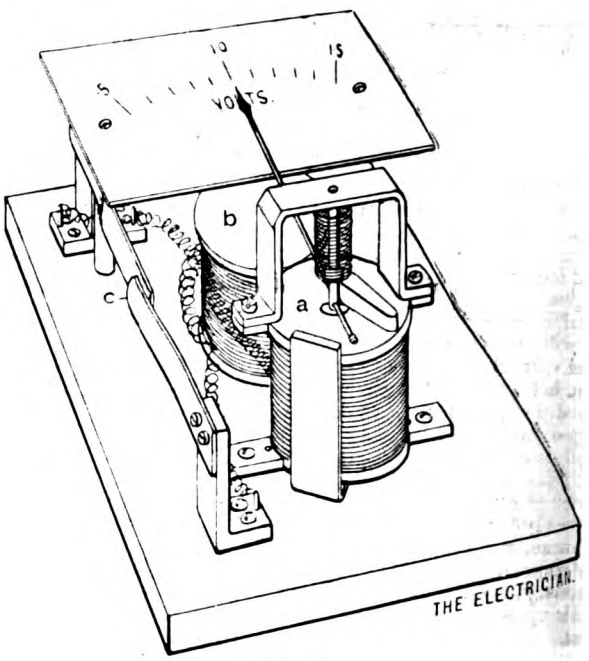

FIG. 1.

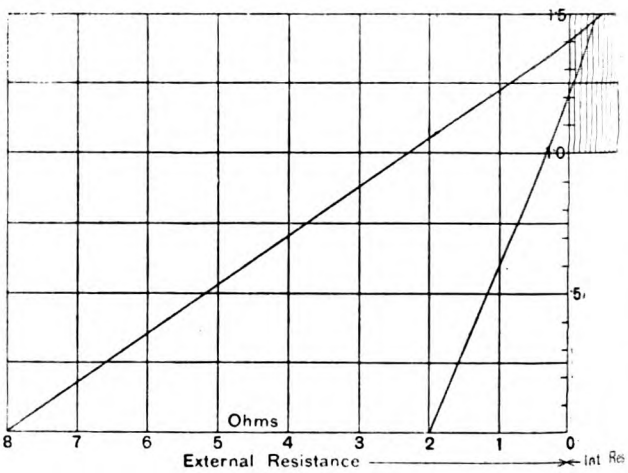

FIG. 2.—Diagram for Calculating Electromotive Force and Internal Resistance of Leclanché, Porous Pot Pattern (New).

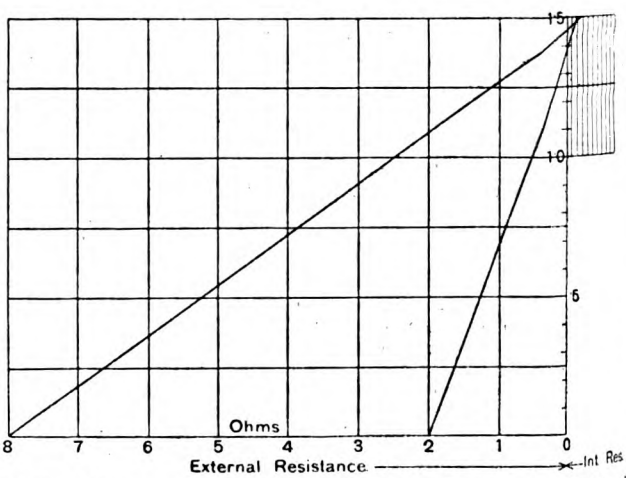

FIG. 3.—Diagram for Calculating Electromotive Force and Internal Resistance of E.C.C. Dry Cell, Special Firing Pattern (New).

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but for the second precaution high resistances are necessary, and these are objectionable because of their great disproportion to the magnitude of the internal resistance which is to be measured.

RAIL BONDING.*

BY C. W. WASON.

This matter of rail bonding is very vital to the interests of street railroads. I am confident that this important branch of the electrical equipment has not been given sufficient attention. I am convinced that a metallic return circuit of equal capacity to overhead feeders must be provided, and that care and attention must be given to the joints in order to reduce resistance and make the metallic circuit perfect in itself.

I will explain and illustrate to you what I consider the best rail bond. In the centre of the rail, that is, longitudinally, I drill a $\frac{17}{32}$in. hole, about 2in. or 3in. from the bottom of the rail. When placed in position on the track on the ties, this hole is then tapped out with a $\frac{5}{8}$in. taper tap. At the shop we prepare a rail bond, one end of which is soldered into a terminal of brass about $\frac{5}{8}$in. thick and 1$\frac{1}{4}$in. diameter with a $\frac{5}{8}$in. hole through. This is tinned carefully all over, and then a galvanised bolt is screwed into the newly-tapped hole through the hole in the terminal; the threads, of course, will fit it, and being tapered, the bolt will be screwed home and make a fairly tight joint even without any solder, if that be necessary. The bolt comes through about one-sixteenth of an inch, and is upset to further insure against the probability of its working loose. One reason for not putting the rail bond at either end of the rail, as has commonly been done, is that the rail will give or spring at the end. Then, again, one rail bond is sufficient to each rail, and only one hole is necessary in each rail. After the nut is set up tight the joint is painted with shellac, covering the bolt and terminal and the wire for a short distance out, say 3in. or 4in. After that has dried two coats of asphalte varnish are applied. The reason for putting on the shellac is that the asphalte varnish does not seem to cling to the iron as well as the shellac does.

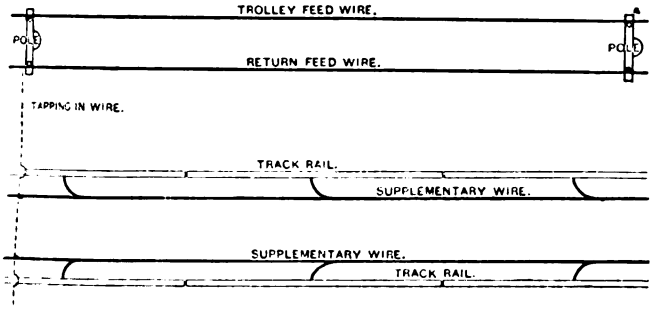

Diagram of Mr. Wason's Method of Rail Bonding, and Return Feeder Connection.

I have drawn a diagram which will possibly illustrate my idea of track wiring. We will call from the left to the right of this sketch 500ft. The rails you see are attached to the ground wire in the centre of each, in the manner I have shown, and at each 500ft. a No. 0 copper wire is connected to each of the four ground wires, or supplementary wires, and run to the pole on the side of the street. It is better if this wire is laid in a box filled with asphalte and run through a pipe which is also filled with asphalte up to the pole. These connections run up at about every 500ft.; they may end there for the present. Heretofore, as the traffic increases on the electric road, an additional feed wire is run out, and in six months or a year another one is run out. Nothing is done with the underground wiring; that remains the same as it was when started. As a matter of fact, it is getting worse and worse each year, and still nothing has been done to re-enforce it. My idea is, as you add feeders, to add return wires and connect these number 0 wires which have been run up the pole when the track was laid. In that way you have got enough copper and metal in the ground to take care of any possible amount of current that you will need to take care of between these 500 foot points. If you fill that track full of cars and started them all at once, which is, of course, a very improbable and almost an impossible condition, you will still have enough metal to carry the current required. Then by having your feeders proportionately large you will relieve the heating and burning out of joints that might be otherwise overloaded.

I think the entire system should be quite independent of the earth for its return circuit; that a return circuit should be provided with copper equal to that which distributes, if you can use these terms.

* Abstract of a Paper read before the Electric Club of Cleveland.

ON THE DISSIPATION OF ENERGY IN A ROTATING ELECTRIC FIELD, AND ON ELECTROSTATIC HYSTERESIS.*

BY RICCARDO ARNÒ.

In a preceding Paper (*The Electrician*, Vol. XXX., p. 516, March 3, 1893), Signor Arnò described a method for producing a rotating electric field by means of a simple alternating difference of potential between two fixed points. This was made, by the interposition of a high resistance and a condenser, to produce two superimposed electric fields, both of them alternating, but the one lagging a quarter-period behind the other, thus producing a continuous rotation of the resultant. A dielectric cylinder suspended in this field was found to follow the rotation of the field itself, a phenomenon which the author attributed to a species of hysteresis in the dielectric analogous to magnetic hysteresis. Since then M. Hess has propounded the theory (see *La Lumière Electrique*, November 26 and December 10, 1892, also *The Electrician*, Vol. XXX., p. 518, March 3, 1893), that the heating of a diele tric substance under the influence of an alternating electrostatic field is due, in part at least, to the presence of conducting particles disseminated throughout the dielectric. Herr Steinmetz (*Elektrotechnische Zeitschrift*, April 29, 1892, also *The Electrician*, Vol. XXVIII., p. 602, April 8, 1892), on the other hand, measured the energy transformed into heat in the conducting layers of a paraffined-paper condenser, and found it proportional to the square of the effective difference of potential. This transformation he attributed to hysteresis in the dielectric layers

The present note was written with the object of describing an apparatus which utilises the rotation of a dielectric cylinder in a rotating electric field for the study of electrostatic hysteresis, and to place on record some results obtained with this apparatus in the case of an ebonite cylinder.

A small hollow cylinder of ebonite was hung by a bifilar suspension between four plates of copper, arranged in a circle and facing inwards, which served to produce the rotating field. A piece of aluminium wire, attached to the ebonite, carried a small mirror, and also a closed hollow cylinder of electrolytic copper, suspended between the poles of a horse-shoe magnet, to render the arrangement dead-beat. The whole was enclosed with a disc of calcic chloride in a metal case connected to earth. The energy consumed while the apparatus was at work was measured on the principle of the friction dynamometer, by the steady deflection produced by a certain rate of rotation. This was done for effective differences of potential varying from 5 to 18 volts, as measured by a Cardew voltmeter. The intensity of the field, calculated from the distance between the copper plates, and the difference of potential between the ends of the secondary coil of the induction coil, as shown by a Thomson electrostatic voltmeter, ranged from 0·95 to 3·33 electrostatic C.-G.-S. units. On plotting the logarithms of the differences of potential (as abscissæ) and those of the corresponding deflections (as ordinates) the curve obtained was sensibly a straight line, showing the law connecting the two to be of the form

$$\log d = \log h + x \log v,$$

where d is the deflection, v the potential difference, and h a constant. Hence this notation could be written

$$d = h\, v^x,$$

or in terms of W the energy absorbed, F the intensity of the field, H another constant, and $x = 1{\cdot}607$, as found by a series of fourteen determinations,

$$W = H\, F^{1{\cdot}6}.$$

In this formula, the exponent of F differs from that required by Hess's theory of conducting particles, and tends to confirm the hypothesis of the dissipation being due to hysteresis.†

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, June 23rd.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1) "Exhibition of a Form of Carey-Foster Bridge," by Mr. Nalder; (2) "An Influence Machine," by Mr. Pidgeon; (3) "An Influence Machine," by Mr. Wimshurst; (4) "A New Volumenometer," by Mr. Myers.

INSTITUTION OF ELECTRICAL ENGINEERS.

9 p.m. Conversazione at the Institute of Painters in Water Colours, Piccadilly.

* *Rendiconti della R. Accademia dei Lincei*. Vol. II. First half-year. No. 8.

† See also Janet, *Comptes Rendus*, CXVI., February 20, 1893, p. 373: "Hystérésis et Viscosité Diélectrique du Mica pour des Oscillations Rapides."

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Editorial, Publishing, and Printing Offices :

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All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co.*"

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ELECTRICITY SUPPLY IN LONDON.

Our analysis of the accounts of the electricity supply companies of London needs less introduction than last year. We have as before taken the Board of Trade forms of accounts and these alone as our basis, and these, as far as they go, enable us to bring all the figures into uniformity. It is to be regretted, perhaps, that no provision was made in the original model form of those accounts for a statement of the actual output of each company. With but one exception, the companies have furnished us with their outputs as metered out of the stations, and these form together an aggregate of 7,915,746 units, as against about 4,300,000 of last year. This increase of about 84 per cent., compared with the small extension of mains during the year, is highly satisfactory. The total receipts have risen from £143,992 to £225,790 ; this is an increase of 57 per cent.; we are not, however, immediately concerned with the financial result or with the price of shares. There is no end to the analyses which *might* be made of the accounts, but we have confined ourselves to our original tables. The least satisfactory columns from the point of view of uniformity are those relating to distribution expenses. In considering these we have only followed the figures of the Board of Trade accounts ; but it is evident that different companies have different ideas on the subject. It is a pity that these were not more clearly defined at first. The St. James' and Pall Mall Company solves the difficulty by declining to separate distribution from generation ; the Westminster Company, who adopted this course last year, have now conformed to the Board of Trade model. The City of London Company has only six months' working to show, and has therefore been omitted.

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Turning to the cost of coal per unit supplied, we find that the companies range themselves in the following order:—

Supply Companies in order of consumption of coal per Board of Trade unit supplied.

	d.
London Electric	2·36
House-to-House	2·1
Electricity Supply (Charing Cross)	1·91
Metropolitan	1·8
Chelsea	1·7
St. Pancras	1·665
Notting Hill	1·355
Westminster	1·047
St. James' and Pall Mall	0·945
Kensington and Knightsbridge	0·92

This table of coal consumption divided itself last year with great simplicity into those above 2d. and those below 2d. The former were all the alternating-current systems, and the latter, continuous-current, the Chelsea Company alone going into the wrong lobby with the alternate-current companies. Last year the House-to-House Company headed the list with 2·7d. per unit; this year, the London Electric Supply Corporation, for no very obvious reason, occupy this unenviable position. It must be remembered that this table is based on the coal-bill, and is not a record of the pounds of coal per unit. The London Company, which has increased its output by 81 per cent., unloads its coal at its own wharf, and one station, the smallest one of the Westminster Company, does the same. The London and the House-to-House Companies alone reach 2d. The simplicity of last year's order is marred by the interchange of position of an alternate-current company with a continuous-current concern. The Metropolitan Company has succeeded not only in getting below 2d., but below the Electricity Supply Company. There is, however, some doubt about the output of this latter Company; we have not succeeded in getting their actual metered output, and have had to deduce it from the revenue and the nominal price per unit. The actual output was, no doubt, greater, owing to contracts with theatres. Of the continuous-current systems, after the Electrical Supply Company, Chelsea is again the highest, but has succeeded in reducing the coal per unit from 2·22d. to 1·7d. Coming to the most economical companies, it is difficult to make strict comparisons. St. James' and Pall Mall are no longer in the proud position of the lowest coal consumption; they have lowered their figure from 1·05d. of last year to 0·94d., but the Kensington and Knightsbridge Company has left them behind, and is to be congratulated on 0·92d. per unit, almost one-half of the Metropolitan Company's figure. Prof. KENNEDY has nearly succeeded in running the Westminster Company for a pennyworth of coal per unit supplied. The statement of quantities generated, sold, used on works for lighting, meter-testing, charging batteries, and lost on feeders, is given with admirable clearness in the accounts of the Westminster Company. No less than 9·9 per cent. of the whole quantity generated was lost on the feeders, and only 1·41 per cent. is put down as having been expended on the batteries.

Two of the alternate-current companies are working at a disadvantage. The load of the London Company is altogether out of proportion to its plant, and the Metropolitan Company has two burdens, one at Whitehall and another at Rathbone place. The Sardinia-street station, while giving but little trouble and doing most of the work, cannot compete in economy with good English plant; and no company has so straggling a district, and probably none so many lightly loaded transformers. The last, however, is a palpable fault of the system, but one which can be remedied. Time will show in what direction alternate-current supply presents advantages for such crowded districts as those of the London companies, and to what extent sub-station transformers will improve matters. The alternate-current system is richly provided with mathematicians and electricians, but it seems to need an engineer of the CROMPTON or KENNEDY order to do justice on broad lines to the ingenuity of the details.

CAPITAL EXPENDITURE up to December 31, 1892, of Statutory Electricity Supply Companies at present at Work in London.

Companies.	Authorised Capital. (Share and Loan).	Paid-up Capital.	Expended Capital.	Details of capital expenditure. — Lands.	Capital Expended.	Buildings.	Capital Expended.	Plant (incl. Tr. nsf rmrs Instruments and Accumulators.	Capital Expended	Mains.	Capital Expended.	Meters.	Miscellaneous.
1. Chelsea Electricity Supply Company	£ 160,500	£ 72,385	£ 81,364	£ 548[1]	% 0·67	£ 10,622	% 13·1	£ 36,673	% 45·0	£ 20,486	% 25·3	£ 3,473	£ 9,562[2]
2. Electricity Supply Corporation (Charing-cross and Strand Electricity Supply Corpor't'n)	220,000	200,900	198,773[3]				193,474				97·4	1,501	5,297
3. House-to-House Electric Light Supply Company	130,000	76,795	69,767	56	0·08	9,374	13·5	28,656	41·2	19,370	27·6	3,127	9,184[4]
4. Kensington and Knightsbridge Electric Lighting Company	425,000	154,400	152,518	5,713	3·75	16,957	11·1	50,954	33·3	56,389	37·0	5,426	17,079[5]
5. London Electric Supply Corporation	1,500,000	836,230	820,740[6]		125,983		15·3	225,190	27·4	155,040	18·9	6,798	58,768
6. Metropolitan Electric Supply Company	1,000,000	549,741	550,860	12,389	2·25	127,640	23·1	211,254	38·4	129,540	23·4	7,955	56,289[7]
7. Notting Hill Electric Lighting Company	150,000	77,850	76,900	7,390	9·6	10,923	14·2	14,889	19·4	33,905	44·2	850	8,943
8. St. Pancras Vestry	100,000	91,269	88,914	10,827	12·2	7,654	8·6	27,625	31·0	33,788	38·0	1,556	7,464[8]
9. St. James' and Pall Mall Electric Light Company	300,000	200,000	195,019	40,910	20·8	27,320	14·0	55,683	28·5	51,454	26·3	3,512	15,375
10. Westminster Electric Supply Corporation	400,000	370,000	351,197	16,917	4·8	72,758	20·7	88,482	25·2	146,880	41·6	11,483	14,163[9]

[1] Includes property subject to £800 mortgage.
[2] Includes £9,283 for Provisional Order and preliminary expenses.
[3] In this amount is included £122,248 for the purchase of lands, generating station, rights, &c.
[4] This includes £7,500 for purchase of patents and covenants with the Managing Director.
[5] This includes £15,000 for purchase of Kensington Court Company.
[6] This includes purchase of Sir Coutts Lindsay and Co., £248,958, equivalent to 30·3 per cent. of total capital expenditure.
[7] Includes £40,805, proportion of management and general expenditure chargeable to capital.
[8] Includes £6,723 spent on public lamps.
[9] Includes £10,133, purchase money of City of Westminster Electrical Syndicate.

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Analysis of the REVENUE ACCOUNTS for 1892 of the Statutory

Companies.	Board of Trade units supplied during 1892.	Price of Board of Trade unit during 1892.	Receipts during 1892.	Expenditure during 1892.	% Ratio $\frac{\text{Expenditure}}{\text{Receipts}}$.	Total Expenditure per Board of Trade unit sold.	Generating expenses.	Per cent. of the year's expenses.	Generating expenses per Board of Trade unit sold.	Distribution expenses.	Per cent. of the year's expenses.	Distribution expenses per Board of Trade unit sold.	Management expenses
		d.	£	£	%	d.	£	%	d.	£	%	d.	£
1. Chelsea Electricity Supply Company	357,162	8	12,523	8,204	65·5	5·5	4,766	58·0	3·2	1,037	12·6	0·7	1,798
2. Electricity Supply Corporation (Charing Cross and Strand Electricity Supply Corpor't'n)	676,013*c*	7	20,658	10,661	51·6	3·8	7,639	71·6	2·74	552	5·11	0·2	1,429
3. House-to-House Electric Light Supply Company	313,484	8	10,689	7,852	73·6	6·1	6,336	80·6	4·85	105	1·34	0·8	752
4. Kensington and Knightsbridge Electric Lighting Company	535,343	8	17,538	10,747	61·3	4·8	6,272	58·4	2·8	978	9·1	0·44	1,636
5. London Electric Supply Corporation	825,090	7	24,282	28,196	116·12	8·6	14,699	52·1	4·27	4,221	15·0	1·23	5,465
6. Metropolitan Electric Supply Company	2,035,000	7½	54,572	*c*40,404	74·0	4·76	27,577	68·4	3·25	293	7·3	0·034	5,470
7. Notting Hill Electric Lighting Company	76,178	8	3,513	3,401	96·5	10·7	1,510	44·4	4·8	357	10·5	1·1	640
8. St. Pancras Vestry (*f*)	433,519	6	11,003	8,427	76·6	4·6	5,735	68·2	3·17	327	3·9	0·181	1,321
9. St. James' and Pall Mall Electric Light Company	1,186,926	7	34,559	21,100	61·3	*a*4·27	11,268*d*	53·4	2·28	—	—	—	3,666
10. Westminster Electric Supply Corporation	1,217,871	7	36,443	24,834	67·5	*b*4·8	13,622	54·8	2·68	1,332	5·3	0·26	3,975

(*a*) This Company sets aside £4,348 to depreciation, redemption, and other charges. (*b*) £3,540 is set aside for depreciation and other charges. (*c*) This Company sets aside £4,000 to depreciation fund. (*d*) Includes distributing expenses, and £1,026 for maintenance of mains.

MR. DENNY LANE ON ELECTRIC LIGHTING.

(Concluded from page 184.)

The latest proposal is what is called "Thermal Storage," by which it is intended to store heat in the form of water, under very high-pressure, in strong wrought-iron vessels—in fact, auxiliary boilers without fires—which would be stocked with water heated by other ordinary boilers working all the 24 hours. This project has been devised by Mr. Druitt Halpin, and is spoken of rather favourably by Prof. Unwin. In the case of a central station, it is stated that at mid-winter 2,000 effective H.P. were required to meet the maximum demand, and ten large boilers should be provided; whereas, if the heat could be stored, three similar boilers working for 24 hours would bo sufficient. Mr. Halpin proposed to store the heat generated in the three active boilers in 24 wrought-iron vessels, 8ft. in diameter and 30ft. high, raising the temperature to 406° F. At the time when the thermal storage was partially exhausted, the temperature fell to 347deg., to be raised again to 406deg.; and it was calculated that, with this range of temperature, 16lb. of water would furnish 1lb. of steam at 130lb. absolute pressure. Taking 18lb. of steam per horse-power, we should, therefore, store up $18 \times 16 = 288$lb. of hot water at a temperature of 406° F., and a pressure of 265lb absolute, for each horse-power required. At present the ten boilers used cost £10,300; while three boilers and 24 high-pressure storage tanks would cost £15,000. But if by the arrangement ½lb. of coal per effective horse-power were spared, the annual saving would be 1,270 tons of coal. This shows the power consumption to be 5,689,600 H.P. hours a year, or 15,600 H.P. hours a day. Now if we divide this by 2,000 effective H.P. it would seem that, in mid-winter, the demand was equal to eight hours of the maximum capacity.

I may add that Mr. Halpin suggests that the waste heat heating the water in his storage tanks; and, taking the escaping from our retort-benches might be utilised for escaping furnace gases at 1,200° F., he estimates that the quantity of heat passing away into the chimneys of our gasworks would supply 30,000 effective horse-power night and day all the year round. But I think he must have taken our temperatures, and felt our pulses, before the regenerative system had been adopted; for, under such a system, no temperature so high as 1,200deg. reaches the chimney. At the same time, I believe that if the draught were not too much impeded some of the escaping heat might be picked up and utilised. Mr. Halpin estimated that it required 319lb. of coke to carbonise a ton of coal, or more than 14lb. per 100lb. of coal. This, of course, exceeds the quantity necessary in best modern settings.

To the complications and heavy initial expense of Mr. Halpin's system, some addition may be requisite on account of working for 24 hours instead of six or eight hours; but the proposal puts an additional grave accent over the already sufficiently grave difficulty of the load-factor.

Now the question arises, Is there any possible solution of this question? I answer at once that there is an easy and a ready solution; and that solution, gentlemen, is in *your* hands. Instead of storing chemical force in accumulators, water at a great elevation, or water at a very high-pressure, store *gas*, employ it in gas-engines, and the question is solved. Years ago I proposed this as the most economical system of supplying the electric light; and I was greatly gratified to find that so high an authority as Prof. Kennedy has lately recommended the same system to the Corporation of the City where we are now assembled. Let us see what capital will be required. For six months of the year, every well-designed gasworks has storage to spare; so that we have to provide additional gasholder-room for the winter only. Under ordinary circumstances, I suppose I may put down the cost of a gasholder at £12s. 10s. per 1,000 cubic feet; and charging 8 per cent. for interest and depreciation, this will come to about £1 a year. If filled and emptied 240 times a year, the cost of storage would be only 1d. per 1,000 cubic feet, or if filled 120 times—or, say, once a day for four months—the cost would be 2d. per 1,000 cubic feet. What will these 1,000 cubic feet do? At 25 cubic feet per effective horse-power, or 33⅓ft. per kilowatt, we get by means of a gas-engine 40 H.P., or 30 kilowatts, for a cost of 2d. for storage. So that, supposing you have to put up a new holder for the purpose, the outlay would be one-fifteenth of a penny for every Board of Trade unit. But I go further, and say that this storage costs less than nothing, if you take into account the cost of attendance on steam-engines, boilers, price of water, carriage of coal into and ashes out of a central station, and the cost of chimney shaft, setting, and repairs of boilers. But the heaviest loss is in the fuel wasted in getting up steam after several hours' rest of the boilers, and the waste of heat if the fires be banked for 20 hours out of the 24. On the other hand, the gas-engine can be started in a few seconds, and there is no waste in the "hours of idleness." Here, then, we have under our own hands the most effectual and cheap system for immediately supplying fuel when wanted, and restoring it in the frequently recurring intervals.

Having disposed of this difficulty, I come to another obstacle in the way of electric progress, viz., the cost of conductors. As long as overhead high-tension conductors were allowed, the difficulty was not so great. But since the Board of Trade nearly always requires undergound conductors, the cost has been greatly enhanced; and two systems have been adopted—for the low-tension system, bare copper rods laid in concrete culverts; and for both low and high-tension, insulated cables generally drawn through cast-iron pipes, which are sometimes filled with oil. Both of these modes are very expensive; and this has led to the transformer system, which is the most important development that has taken place during the last dozen years.

The transformers are of three totally different kinds, as they are to be used by the continuous or alternating current. In the first

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Electricity Supply Companies at Work in London.

Per cent. of the year's expenses.	Management expenses per Board of Trade unit sold.	Rent, rates, taxes, &c.	Per cent. of the year's expenses.	Rent, rates, taxes, &c., per Board of Trade unit sold.	—	Coal.	Per cent. of generating expenses.	Cost of coal per Board of Trade unit sold.	Oil and waste, &c.	Per cent. of generating expenses.	Cost of Oil, &c., per Board of Trade unit sold.	Salaries and wages.	Per cent. of generating expenses.	Salaries and wages per Board of Trade unit sold.	Repairs and Maintenance.	Per cent. of generating expenses.	Cost of repairs and maintenance per Board of Trade unit sold.
%	d.	£	%	d.		£	%	d.	£	%	d.	£	%	d.	£	%	d.
21·9	1·2	516	6·3	0·37	Details of generating expenses.	2,433	51·0	1·64	754	1·58	10·5	1,057	22·2	0·71	521	12·0	0·35
13·4	0·5	696	6·52	0·25		4,189	54·8	1·49	573	7·5	0·2	1,746	22·8	0·62	993	13·0	0·45
9·6	0·57	428	5·5	0·33		2,808	44·4	2·15	791	12·5	0·6	2,004	31·7	1·53	659	10·4	0·5
15·25	0·73	936	8·7	0·42		2,053	32·8	0·92	431	6·9	0·19	1,344	21·5	0·6	2,443	39·0	1·1
19·4	1·59	2,943	10·4	0·85		8,128	56·2	2·36	1,437	9·8	0·42	3,760	25·6	1·09	1,373	9·35	0·5
13·5	0·65	2,645	6·5	0·31		15,278	55·5	1·8	2,165	7·8	0·25	6,653	24·3	0·79	3,481	12·7	0·412
18·8	2·0	386	11·3	1·2		431	28·5	1·35	114	7·56	0·35	596	39·5	1·8	351	23·0	1·1
15·7	0·73	—	—	—		3,011	52·6	1·66	434	7·56	0·24	1,983	34·5	1·2	262	4·6	0·145
17·3	0·74	818	3·9	0·165		4,673	41·4	0·94	591	5·2	0·1	3,769	33·4	0·76	1,209	10·7	0·245
16·0	0·784	2,364	9·5	0·466		5,313	39·0	1·047	1,282	9·4	0·25	5,776	42·4	1·14	1,250	9·1	0·246

(*e*) We were unable to obtain from this Company the total number of units supplied, and they have been calculated from the sale of current.

(*f*) Being a Local Authority no amount is set aside for rates and taxes.

case, the transformer consists of an electric motor made to revolve by the current; the same axis carrying a dynamo, the revolution of which in a magnetic field generates a current of lower voltage In the first step, the electricity is converted into motive-power, which is again converted back to electricity. The first may be a current of high-tension requiring a cheaper conductor; and the secondary current may be of the lower tension used in electric lighting. As in each of these conversions we get out (say) 86 per cent. of what we put in, the result is about $0{\cdot}86 \times 0{\cdot}86$, or under 57 per cent. of the originating current, without counting the loss in the primary main. For the low-tension system another plan has been used, viz.: four sets of storage cells are charged in series by an originating current of (say) 400 volts, until each set can give a tension of 100 volts. They are then disconnected from the charging mains, and discharged separately through the service mains at 100 volts. The object of the whole arrangement is to diminish the cost of the conductors in the ratio of over 3 to 1; but the heavy loss incurred by storage cells, their great cost, and rapid deterioration, are inseparable from this system.

As a motor actuated by an alternating-current has not yet come into practical use, another device has to be resorted to, the germ of which, as well as of those of many other inventions, is to be found in Faraday's earliest Papers on the subject. Taking a soft iron ring, he wound on different parts of it two coils of insulated copper wire. On making or breaking a battery current through one of these coils, a momentary current was produced in the other. The alternate-current transformer of the present day consists essentially of the same parts, viz., a soft iron core wound with two coils; one of thin wire through which the original alternating-current is carried, and the other of thicker wire through which a current of lower tension is generated fit for electric lighting. A common proportion is 2,000 volts reduced to 110 volts.

Now the only object of all these transformers is to diminish the cost of the conductors from the Central Station; and the relative cost of conductors depends on this principle. What the electrician sells is a watt; but the watt, like the foot-pound (to 44 of which it is equivalent), is a compound unit, being the product of the volt and the ampere. To secure a given product, we may make one factor very small by making the other very large—1lb. falling 1,000ft. is the equivalent of 1,000lb. falling one foot. Now the heating of the conductor, and the dissipation of energy as heat, in no way depends on the volts, but altogether on the amperes being proportional to the square of the amperes, multiplied by the resistance. Small wires offer more resistance than large ones; and to secure a sufficient number of watts through them, we must increase the volts and lessen the amperes, which alone cause the heating and loss of energy. The whole object, therefore, of these systems is to diminish the cost of the conductors; and it seems now to be generally agreed among practical men that it is not economical to send more than 1,000 amperes per sq. in. as the maximum current that a copper conductor can safely carry—a quantity which, at 100 volts, would supply about 750 16 c.p. lamps. But I find that Mr. Crompton, in his celebrated Paper on the relative efficiency of alternate-current and battery transformers, allows only 720 amperes per sq. in. Mr. Crompton says that a double conductor, each of $1\frac{1}{2}$ sq. in. section, shall be used for 1,080 amperes. At 110 volts, it requires about 7 amperes for a horse-power, so that the 3in. of copper gives only 154 H.P. It would, therefore, require two sets of these double conductors to deliver as much power as a 6in. gas-main could carry; and the cost, instead of £500 or £600, would now run up to £1,100. If the gas-pressure was increased to 16in. the corresponding electric conductors would cost £22,000. If the alternate current is employed, the insulated cables would, by Mr. Crompton's calculation, cost 2·63 times as much. Besides this, there would be considerable loss of electricity, and practically none of gas, in a main laid specially for the purpose, and not tapped for service-pipes.

But this change of tension cannot be effected without loss. My friend, Mr. Mordey, appears to have been very successful with the closed, while Mr. Swinburne advocates the open, Hedgehog transformer. What the loss is I would be afraid to say; but it used to be laid down that these transformers had a high efficiency when on a full load, but showed great loss at low loads. Originally each house was supplied with a separate transformer. Now, I believe, the transformers are "banked," using a large number, or those of large size, for the heavy hours, and a smaller number for the light hours. I must say I am rather surprised at the high yield claimed for some of them; and I should like to see some reliable return of the number of watts put into the main at the station and the number paid for by the consumer, for this is really the financial question to be settled. Dr. Fleming, who has devoted so much time and ability to this subject, estimates the efficiency of both forms open and closed throughout the 24 hours at 75 per cent. At Deptford they only hope for 70 per cent.—representing a truly formidable loss.

Is there any way of getting out of this difficulty about conductors? I allege there is; and again I say the remedy is in *your* hands. Instead of distributing electricity, distribute *gas* to be used in gas-engines near the spot where the electricity may be required. When, about a year and a half ago, I began to investigate the question seriously, I was surprised at the great economy of "distribution of energy by gas." Of course, it was only potential energy; and it would have been more correct to speak of the distribution of gaseous fuel.

The Editor of *The Electrician* was good enough in October, 1891, to publish a letter of mine on the subject, every statement of which has remained without contradiction. I took as an example a 6in. gas-main, which would not cost more than about £500 or £600 a mile. Such a main would, at a pressure of 4in., deliver at a dis-

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tance of one mile 9,000 cubic feet of gas, which should yield 300 to 400 H.P. I showed that the power necessary to force the given quantity of gas at the given pressure was only one-tenth of a horse-power. I thus arrived at the result that we can send as much gas as will supply 3,000 to 4,000 H P. one mile for 1 H.P., costing ¾d. Of course, by raising the pressure to 16in., the delivery would be doubled, and the power quadrupled ; so that we could still send 6,000 H.P. one mile for 3d. This, I must say, is an extraordinary result, especially when you compare it with the efficiency of other modes of transfer of force so clearly explained by Mr. Kapp and Prof. Unwin.

Now let us take a glance at hydraulic transmission by a 6in. main, which, of course, for 750lb. pressure, must be far more expensive than a gas-main which has to bear only ½lb., or the 1,200th part of that in the hydraulic main. This expensive 6in. main will carry only 116 H.P., instead of the 600 H.P. which the cheaper gas-main can convey ; and while there is no appreciable loss on the gas-main, there is a loss of 20 per cent. on the hydraulic main. The cost per horse-power by high-pressure water may on an average be put down at 14d. for small, to 5d. for the largest powers, against ¾d. per horse-power for gas.

To revert to the question of storage, I may give Prof. Unwin's figures :—

The capital cost for storage of 1 H.P. hour is estimated by him as follows :—

Gas	£0	5	6
Thermal storage with condensing engines	1	13	0
Do. Do., non-condensing engines	2	5	0
Epstein storage cells	8	0	0
Storage cells at Frankfort	23	0	0
Storage cells Mr. Kapp gives as £30 to £37			

Next with respect to loss in storage—

Gas	0
Storage cells—average	20 per cent.
Transformers, high tension	25 „
Storage battery, transformers	25 „
Thermal storage—not ascertained, but considering loss by radiation, say	20 „

Loss in transmission—

Gas	1
Electricity	10 to 30 per cent.
High pressure—hydraulic	20 „
Low pressure, as at Edinburgh	50 „

It may seem strange to some minds—especially those with municipal interests—if I make the following statement : I think it is a pity that the electric light was not handed over to those who were already the purveyors of light to the public, I mean the gas manufacturers. In some cases this system has been recommended ; but even where gas companies work independently of the Corporations, I believe that they could supply the light on better terms than any separate organisation. The reasons why I believe this result could be obtained are : (1) There would be no necessity for a second staff of directors, secretaries, engineers, accountants, collectors, &c. (2) In most cases there would be no need to purchase or rent any additional land. (3) A considerable portion of the existing staff of the gas-works could manage engines (and even boilers, if such were required) with little additional cost. (4) The storage can be provided at a very low cost, and so eliminate the great difficulty arising from the great fluctuation of demand beween 1 unit and 80 units. (5) If generating stations are placed at a distance from the works, the feeding gas-mains cost very little ; the power employed for transmission is infinitesimally small ; and the loss by leakage practically nothing. (6) The cost of production per unit is very much lower than by any other system. I believe that in most cases gas of low illuminating, but good heating power, can be produced on the works for 1s. 6d. per 1,000 cubic feet and leave a profit ; no outlay having to be incurred for mains, services, and meters—mains being charged as conductors.

As an example of what may be done with even a small plant worked with three 16 H.P. nominal gas engines, and using 70 "E.P.S." cells of the "K" type, I quote from actual working returns—

The average of the results for August and October gives the cost of—

Town gas at 3s. 3d. per 1,000 feet as	1·550d.	per unit.
Labour	0·425	„
Oil and waste	0·014	„
Water	0·033	„
Total	2·022d.	per unit.

If, however, heating gas can be made at a profit for 1s. 6d. per 1,000 feet, the first item (cost of gas) would be reduced to 0·71d.; and the whole cost would be only 1·182d., or considerably under 1¼d. per unit, a cost less than is incurred in many cases where water power is employed.

I may add a few examples from Ireland. Electric lighting was started in Waterford some years ago, and the price charged for each arc lamp was £26 per annum (subsequently reduced, I believe, to £23), although the printed statements of the contractors would seem to show that the lights cost £32 each. The consequence was that the snake had bitten the infant, who died a short time since from the effects of slow poisoning ; and electric lighting has ceased in Waterford, although the steam-engines were described as "beautiful compounds." In our own immediate neighbourhood, at Larne, a town of 4,200 inhabitants, works were established by Messrs. Gordon and Co.—a firm which had immediately before declared a dividend of 30 per cent. A short time since, the able head of the firm, Mr. J. H. Gordon—a man of great and very varied attainments—lost his life by a melancholy accident. This, I suppose, disorganised the Company's business, for the plant, which was said to have cost them £8,000, was offered to the Town Commissioners for £6,000 ; but the offer was declined—one of that body stating that, at the best, six years would elapse before the concern could pay the working expenses. In Carlow, a town with a steadily-declining population of only 9,000 inhabitants, works have been established. The current is generated by water power four miles distant from the town ; but, as far as I can learn, the income of the Company could scarcely pay the rent, the upkeep of the plant, and any fair salaries to the officials English people can hardly understand how small is the number of inhabitants in an Irish country town who can afford to pay for any luxury, or incur any expenditure save what is strictly necessary. If the city of Waterford—an important port, where several lines of railway converge—with a population three times as large as that of Carlow, could not support a central station, I do not see how the latter can be successful. But Killarney, with a population of 5,500, is boldly venturing upon a similar experiment, although the town is a "Sleepy Hollow" amidst beautiful scenery except for a few months in the summer and autumn, when artificial light is not much required.

I had intended to make some observations on the testing of illuminating power, founded on the idea that the producers should get some credit when they give more than the parliamentary standard ; and, in fact, be credited with the average within certain limits. The Board of Trade has recognised this reasonable system in the case of gas meters—allowing a variation of 5 per cent., and something similar in the case of electrical tension, although a difference of 1 volt may make a difference of 5 or 6 per cent. in the light. But I have already occupied your time too long. I cannot, however, leave the main subject of this address without expressing my obligations to Mr. Thomas Patrick Travers, Assoc. Inst. C.E., and a member of the Institution of Electrical Engineers, a young engineer of great promise, who has practically studied electricity as well as gas supply. He has pointed out to me many of the facts which I have detailed to you, and has checked my statements. I think it would be well if many of our members would imitate his example, and give attention to the new lighting agent, as I have shown it is so closely connected with our future interests.

It is now more than ten years since, at the Gas and Electrical Exhibition at the Crystal Palace, you wanted me to express my views. I pointed out that in 1810, as now, the best mode of distribution was by copper wire, and the best wick for the electric lamp was carbon. Sir Humphry Davy had established these facts. But in the generation of electricity from mechanical force, an enormous advance has been made since the time when, over 80 years ago, this "new planet" first "swam into the ken" of the great philosopher ; and what is most remarkable is the fact that this marvellous growth was derived from two small laboratory experiments. First of all Oersted, in 1819, discovered that a magnetic needle suspended on a pointed pivot was deflected if an electric current was passed through a wire in its vicinity, and parallel to it ; and thus electricity produced mechanical movement. It seems strange that no one thought of trying the converse—namely, whether moving the magnet mechanically would produce a current in the wire—until 1831, when Faraday made his great discovery that, in a conductor moved into or out of a magnetic field, a momentary current was produced as it crossed what he called the "lines of force." Everything that has been done since then by Siemens, Gramme, Wilde, Wheatstone, Sadd, and others, is but the natural growth of the seed that germinated in the fertile soil of Oersted's and Faraday's intelligence. And what a growth it has been ! The telegraph, the electric light and traction, and the transference of power for over 100 miles, conversations carried on between two people separated by 1,000 miles, electro-metallurgy, the separation of rare metals from their matrices, and the thousand offices performed by this deft and willing servant of man. When your practical man scoffs at what he calls the toys of science, let him reflect on the momentous issues of these two simple experiments. In the whole history of practical science nothing is so amazing as the development of dynamo-electric energy. Compare it with the steam-engine. Now, nearly a century and a quarter after Watt's great discovery, engineers can convert into power only 10 per cent. of the heat

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evolved in the boiler furnace; and, in not much more than a decade after the invention of the dynamo, over 90 per cent. of mechanical power had been converted into electricity—a sudden bound from tentative and moderate success to practical perfection. Brilliant as is the fame that irradiates the memory of Watt and his disciples, a far brighter mead of praise is due to Faraday's successors, who in so short a time eclipsed the glories of a century. And this important deduction is to be made, that it is "beyond the wit of man to devise" any system by which a larger yield of electricity can be gathered from a given quantity of mechanical force. The Goddess sprung full-armed from the brain of the philosopher.

And when we remember the small grain that was sown, and the mighty tree under whose branches we gather and find shelter, let us venerate the memory of those who devoted their lives to science, and remember that the observation of minute phenomena may, as the weather-marks in the tree guide the Indian warrior, lead us into new paths of progress, open out new vistas of thought, carry us into new fields of industry, and, by raising our thoughts from small effects, lead them to contemplate the great causes that surround us and govern our lives. Every new observation enables us to learn something more of these laws of Nature which, if misapprehended, lead to failure on failure, but which, if rightly understood, may minister to the physical well-being of man, and elevate his mind to those loftier planes of thought where he will stand but little below the highest intelligence. As he rises from level to level, his horizon widens, and each generation gathers a broader view of the vast expanse which Nature spreads before it with all the variety and beauty of a garden and the grandeur of a woodland, interspersed with the sheen of many a sunlit lake, and the sober shadows of alleys sheltered beneath the lush verdure of overhanging arches of the primeval forest.

PARLIAMENTARY INTELLIGENCE.

THE ELECTRIC POWERS PROTECTION CLAUSES.

The Joint Committee of both Houses of Parliament, appointed to consider the questions of protective clauses to be inserted in private Bills relating to electric traction Bills, met for the first time at Westminster on Monday (Lord Cross presiding). The other members of the Committee are Lord Clifford of Chudleigh, Earl Russell, Lord Rosse, Lord Ker (Marquis of Lothian), Mr. Brunner, Mr. Forwood, Major Darwin, Mr. Molloy, and Sir Bernhard Samuelson.

The Counsel appearing were: Mr. Pember, Q.C., Mr. Fletcher Moulton, Q.C., and Mr. R. Wallace, for the National Telephone Company; Mr. Pope, Q.C., for the gas and water companies, and, with Mr. Fletcher Moulton, Q.C., and Mr. E. Moon, for the railway companies; Mr. Cripps, Q.C., and Mr. J. C. Graham, Q.C., for the electric tramway companies and the electric underground railway companies; Mr. Balfour Browne, Q.C., and Mr. Worsley Taylor, Q.C., for the municipal corporations (England and Scotland); Mr. Hans Hamilton, for the Tramway Institute of Great Britain and Ireland; and Mr. R. Hunter, for Her Majesty's Postmaster-General. On behalf of the electric lighting companies and the London County Council there were no appearances.

The solicitor in the interests of electric traction is Mr. Sydney Morse; Messrs. Waterhouse, Winterbotham, and Harrison are solicitors for the National Telephone Company: and Messrs. Bedford, Monier, Williams, and Robinson are the solicitors for the interests of the gas and water companies.

We understand that there is no proposed clause before the Committee, as has been stated in the daily press.

The following is the motion on which the Committee has been appointed:—

"*Electric Powers* (*Protection Clauses*).—That a Joint Committee of Lords and Commons be appointed to consider and report whether the grant of statutory powers to use electricity ought to be qualified by any prohibition or restriction as to earth return-circuits, or by any provisions as to leakage, induction, or similar matters; and, if so, in what cases and under what conditions. And if the Joint Committee are of opinion that any such prohibition, restriction, or provision should be enforced, to settle the necessary clauses. That a message be sent to the Lords to communicate this resolution, and desire their concurrence."

MONDAY, JUNE 19TH.

Sir COURTENAY BOYLE, K.C.B., was the first witness called. In reply to the Chairman, he said that as permanent secretary to the Board of Trade he had had all the questions about the telephones and the circuits submitted to him. The telephone and telegraph companies (in which he included the railway companies using the telegraphs) had sought for protective clauses in the Electric Lighting Provisional Orders, in Tramway Provisional Orders, and in Tramway Bills; that was to say, the telephone companies had sought to avoid interference with their circuits by tramway companies using electricity for traction purposes, and by electric lighting companies when they used high currents on their circuits. The telephone and telegraph companies, speaking generally, used the earth for the return, but not invariably so. But some sections of the telephone system, and, generally speaking, the General Post Office telephone system used the metallic return. The earth system was, however, very largely used by the telephone companies. The action of Parliament had not been uniform. There were four clauses which had been from time to time adopted by Parliament; one called the "Plymouth clause," which was inserted in six Bills in 1889. The effect of those clauses was to give varied degrees of protection to the telephone companies. In some of the clauses the protection was to be given in respect of lines existing and afterwards to exist. The degree of protection given by the four clauses varied very considerably.

The CHAIRMAN: Is it, in your opinion, desirable that this question should be settled in order to have a model clause?—Yes; the Board of Trade found, as regarded Provisional Orders, the telephone companies were again pressing, and reasonably so, for protection to be given to them. There was a variety of practice by Parliament, and by the Board of Trade, with regard to Provisional Orders. After a meeting held at the Board of Trade a representation was made to the Chairman of both Houses by the Board of Trade, suggesting that it was desirable that Parliament should lay down a principle governing the amount of protection, if any, which the telephone and telegraph companies were entitled to receive in this matter. Sir Courtenay Boyle then explained the meaning of the word "ohm" as the unit of resistance, and the other units, the volt and ampere. The telephone companies used the earth for their return circuit generally speaking. The telephone and telegraph companies used very small currents at very low pressure. The telephone, not for the purpose of ringing a bell—that was done by telegraph—but for the purposes of the current used in conversation, was a very small current indeed, something like a millionth part of an ampere. Speaking generally, the telegraph companies used currents from one hundredth part to a quarter of an ampere at a pressure of from 10 to 50 volts. The electric lighting companies used a current of something like 100 to 5,000 amperes at a pressure of 100 to 10,000 volts. Therefore, the Committee would see, as regarded the electric lighting companies, and, similarly, as regarded tramway companies, although theirs was not so high, the current used was very high as compared with the current of the telephone companies. Therefore, the phrase had been used over and over again that this was a matter of electrical disturbance, and the electric lighting companies and the tramway companies were the wolf, and the telegraph and telephone companies were the lamb in this matter. There was no doubt that either by leakage or by induction, the tramways, when they used electricity, might inadvertently cause electrical disturbance in the vicinity of their circuits. That disturbance caused material interference with the very delicate, sensitive instruments used by the telephone companies and the telegraph companies. The metallic return circuit was used in some systems. The telephone companies have got the earth, and used the earth, and they pleaded to be allowed to use the earth by prescriptive, as well as by inherent, right. Electric traction, both on tramways and railways, was growing in popularity, and would grow still more if the question of the use of the earth return could be settled.

Have there been any decisions on the question?—Yes, the case known as the Leeds case, which was between the National Telephone Company and the Leeds Corporation. A special inquiry was organised by Mr. Macrory, whose report showed that undoubtedly there was interference with the sensitive instruments of the National Telephone Company. In delivering that judgment, Mr. Justice Kekewich said, "True it is that the analogy introduced above," that is, the use of land for extraordinary purposes, "holds to this extent: the plaintiffs are using the land for extraordinary purposes"—the plaintiffs being the Telephone Company—"but admittedly it is a lawful purpose, and though under an obligation to obviate mischief from their own operations to their neighbours, they are under none, in my judgment, to protect themselves from the defendants or others." The learned judge went on to say that the defendants' plea was good in law, and they are not responsible to the plaintiffs for any mischief caused by their working. The defendants' authority was derived under a Provisional Order confirmed by Act of Parliament. A little further on the Judge said: "The defendants are expressly authorised to use electrical power, and the Legislature must be taken to have contemplated it and to have condoned by anticipation any mischief arising from the reasonable exercise of the power." Practically, the defendants, that is to say, the Tramway Company, enjoyed certain advantages from the decision, because they had a Provisional Order confirmed by Parliament.

Mr. FORWOOD: Assuming that there is no electrical disturbance such as you have described in a district used by the telephone, would the use of the earth as a return circuit give us as good a result in point of hearing as would a metallic circuit?—That is a scientific question which I can only answer to a certain extent. When the earth is used as a return circuit for telephoning, it must follow that there is a certain amount of electrical disturbance. I think I should have the support of the telephone companies' experts, when I say that perfect telephoning is done by metallic circuiting and not by earthing at all.

Mr. BRUNNER: Are there no more cases of mischief resulting from electrical disturbance than those you have mentioned?—The number of tramway companies using electricity at present is very small, and the electric lighting companies are forbidden to use earth, so that the danger does not, and cannot, occur very often; but if you sanction electricity for traction purposes, the number of instances in which there might be danger would grow.

Earl RUSSELL: The argument is that the expense is much less to the telephone companies to use the insulated returns than to the tramway companies?—That is the argument advanced by the tramway companies, and there is a great deal of weight in that. The tramway companies say it will cost us a very great deal to protect our system absolutely from danger. It would not cost the telephone companies very much, and on the other hand, the telephone companies say, "We have established a very large and far-reaching system of telephoning, which is very largely in the interests of the public, and we do not see why we should be obliged to alter our system because other people may injure us."

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Lord CLIFFORD: With regard to tramways, do any tramways use earth returns?—Not intentionally. I think I am right in saying that there is no railway company or tramway company which deliberately uses an earth return. Earthing occurs by accident and by mishap, but not by intention.

Sir BERNHARD SAMUELSON: Do the electrical tramway companies admit responsibility regarding accidents occurring through leakage or earthing?—They say it is almost impossible; the phrase used is "absolutely impossible." There is an instance brought forward from Buda Pesth, where it is stated that it has been done.

The CHAIRMAN: You are representing neither one interest nor the other; you have simply come to put before us the matter as it was placed before the Board of Trade?—I have no interest whatever to represent. The difficulty has been so overwhelming that the Board of Trade itself has decided as regards its own Provisional Orders that we had better appeal to a stronger tribunal to settle what we had better do.

Mr. PEMBER said they proposed to call a witness who had examined the tramways at Buda Pesth.

The CHAIRMAN: I understand the Post Office wish to be represented here.

Mr. HUNTER said the Post Office at present was rather in the position of watching the Committee. The Post Office had no grievance against the tramways companies or the railway companies at present, because they were protected by what they thought were sufficient clauses. But his Lordship would understand that the Government must reserve to itself the right at any time to seek such protection from the hands of Parliament as they thought necessary. Of course, he was speaking with all respect.

The CHAIRMAN said that if Mr. Preece wished to say anything, the Committee would hear him.

Mr. PREECE was then called. In reply to the Chairman, he said that he was engineer-in-chief and electrician to the Post Office, and President of the Institution of Electrical Engineers. He had given a great deal of attention during the past ten years to the disturbance created in the existing wires by the new and important applications of electricity to electric lighting, and to the working of railways introduced during that period. They had found their telegraphs and telephones were gradually being disturbed. The disturbance arose from two causes: The first was due to the passage of currents of electricity through the crust of the earth; and the second arose from what was called induction. The currents through the earth were the more serious ones. The effects due to induction were easily removable, but, of course, it would cost money. The earth had, from the earliest days—from 1837—been used for the return half of the circuit in telegraphs. A wire, say, extended from London to Glasgow. In London it was usually attached to the great water and gas-pipe system of London, and there it made contact with the earth; in Glasgow the same. When they dealt with the great mass of the earth between London and Glasgow, that resistance was practically nothing. The result was that, electrically, they only had to deal with the resistance of the overhead or underground wire between London and Glasgow. The whole telegraphs of the world at the present moment were worked with the use of the earth, and the telephone, being the child of the telegraph, had originally, in America, also used the earth as part of the circuit. The first telephone which was fixed in London was fixed on a metallic circuit. Ever since then the Post Office had invariably used metallic circuits. The Telephone Company, on the other hand, in their town systems used the earth, but in their trunk systems, which were very extensive, used metallic circuits. On railways, where telegraphs were used for the regulation of traffic, and where electric block signals were used, the earth was used; so that at the present moment the earth was used universally for telegraphs on railways and for Post Office Companies, almost universally for block signals, and very generally indeed for telephones. With the electric light the earth was forbidden, except as provided by Clause 9 of the model Provisional Order. Under Clause 9 the use of the earth was allowed by the Board of Trade, and had been approved of by the Postmaster-General in the case of the London Electric Supply Company. He had prepared a diagram showing how a district became permeated with earth currents. The City and South London Electric Railway started working in 1890. It did not designedly use the earth The return circuit was made by means of the rails, and also the two tubes of the railway took up some of the return currents, acting as the earth. There were two metals to carry the train, and there was a third metal in the centre which enabled the locomotive to pick up the current. The current when picked up passed through the electro-motor on the locomotive, and went through the wheels to the metals, and, theoretically, it ought to go entirely through the metals back to the central station; but, as a matter of fact, it did not. The metals were uninsulated, and the electricity leaked. He exhibited an imaginary diagram, to illustrate what took place when a train was about to start at the Monument at one extreme end, and also what took place when there were two other trains on the line. The curves showed the direction of the earth currents. These earth currents extended to such a distance that they had disturbed the observing instruments at Greenwich, and they were observed also as far away as North Walsham, in Norfolk. The currents passed through a wire extending from London to Norfolk, and they were there recorded on instruments. In order to identify these currents, and to be quite sure that they were due to the working of the train, they took a part of the Norfolk circuit—that was to say, between the General Post Office and Tottenham—and watched for those varying fluctuating currents, and he had marked the currents on his diagram as they rose up and down, and followed exactly the movements of the trains. At Greenwich, when the train service ceased at night the disturbances ceased at the same time. The observations at Greenwich and those at the Post Office always tallied exactly with the working of the traffic. After reference to the effect of leakage currents observed in the south of London, Mr. Preece said that he was rather anxious to impress on the Committee the importance of this question of electric pressure found between gas and water pipes, for it was by far the most serious disturbance that was likely to be brought about. The effect of it would be, if not checked, that the water pipe, or the gas pipe, whichever was connected with the positive side of the current, would, in course of time, be decomposed away. The constant action of the current meant electrolytic decomposition, and unless some steps were taken to prevent this there would certainly be leakage of gas, or leakage of water, and accidents would follow. Sir Courtenay Boyle mentioned the fact that such decomposition occurred in Preston. Major Cardew had personally examined these things, and perhaps he might be called before the Committee to give personal evidence. There was also a great source of danger to the block system of the railway companies. In the year 1880, he thought the London and North-Western Railway Company lighted up the harbour at Holyhead with the electric light. They had five arc lights, with five dynamos. The first effect was to break down their block signals. Their block signals got very much disturbed within a mile of the station, but that was completely cured by making the block signals with a metallic circuit. The Post Office maintained nearly all the block signals in Ireland, so that as a maintainer of block signals his experience was quite as great as that of most of the railway companies in the country. The moment a train stopped, the earth current suddenly rose, as there was a great rush of electricity to stop the train. At that moment a powerful current is sent through the whole region of the earth around the tramway, and the block signal in the case of a railway company is lowered to "all clear," and obviously that might lead to very serious danger. That might be averted by a metallic circuit on the block signals affected. As a rule, the disturbance only extended about half-a-mile to a mile—the average would be about half-a-mile, and it would only be necessary to put up a second wire for those block signals which were likely to be disturbed. He had had the Liverpool overhead railway as carefully examined as the South London Railway, and the curves there were exactly similar. In the case of Liverpool, however, the metals were planted on continuous wooden sleepers, and they did not make very much earth, the result being that the currents were very much less in intensity; there was partial insulation, in fact. In the case of the South London Railway he had not yet heard of any absolute disturbance to any block signal, or even to a telephone. He had taken the South London Railway as an indication of what they were likely to see. If all London were percolated with electric railways, as they hoped it would be, then the injury was almost certain to be serious. He should like to mention that at Blackpool the same current which lowered the railway signal also fired the time current. There, at one o'clock, the Post Office transmitted a current from Greenwich to Blackpool, and this time current had been fired a minute or so before its time by these currents from the electric tramway. In his view, the use of the earth by railways and tramways should be subjected to the supervision or the approval of the Board of Trade and the concurrence of the Postmaster-General, as in the case of the electric lighting companies. He did not go so far as to say that the accidental use of the earth should be prohibited—it could be used under proper supervision. There was on difficulty whatever in virtually insulating the metals in the South London tubes. He thought the current from that railway had increased owing to imperfection in the joints of the tubes.

By Mr. MOLLOY: The disturbance at Holyhead was avoided entirely by metallic insulation. In that particular instance they would have done better if they had made a return for their electric light circuit. In the case of the South London Railway this indiscriminate and accidental use of the earth must mean a very considerable waste of energy, and the working expenses at their central station must be increased considerably by this energy which is wasted in the earth.

By Earl RUSSELL: It was true that the energy required to ring the division bell did not amount to the thousandth of a horse-power; but it must be remembered that that was picking up the energy in a house which was an infinitesimal fraction of the area disturbed by this railway. The disturbance recorded in Norfolk was observed on a wire from the General Post Office. It was not disturbed along the earth all that way; it merely recorded the fact of the disturbance at Stockwell.

By Mr. FORWOOD: As regarded the Post Office telephones, they always used metallic currents, and he did not think a telephone circuit was complete or perfect without a metallic circuit. But the earth was absolutely essential for the working of the telegraphs. They could scarcely work their complicated multiplex and quadruplex system of telegraphs if they used return wires. If they used return wires the whole efficiency of the service would be reduced one-half, the cost of maintenance would be doubled, and the cost of working would be doubled, therefore, financially, it was impossible to use return wires.

In reply to the CHAIRMAN, at the request of Mr. Pember, the Witness promised to inform the Committee subsequently how many miles of telephone the Post Office possessed. They had about 7,000 telephones, and they were now erecting about 4,000 or 5,000 miles, so that he would be within the mark when he said that they had perhaps 20,000 miles.

The CHAIRMAN: Could you repeat those experiments at Greenwich, and let us have the result of them again?—Yes.

Lord ROSS then took the chair, Lord Cross being called away by other Parliamentary business.

Mr. POPE asked if the witness might be allowed to explain what he meant by accidentally using the earth.

Mr. PREECE said that no tramway company, as far as he knew, designed their electrical system so as to use the earth intentionally as the return, but it happened that when it rained, and when the bare copper wire was in connection with the ground then the earth came in accidentally to assist the transfer of the current and then the disturbance was observed.

By Mr. FORWARD: Alternating currents would not affect the gas and water pipes, but continuous currents would. In the case of continuous currents the disturbing effect could be very much diminished by replacing the whole of the gas system, and the whole of the water system in

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direct communication with the return system of the railway, so that with proper supervision the disturbance might be relieved.

By Sir BERNHARD SAMUELSON: He should qualify what he had said about all the telephone circuits of the Post Office being metallic. They had in some outlying districts of Ireland and Scotland, single wires for short distances. In those cases, they did not come near any telegraph; there was no electric light and no disturbing influences anywhere near; therefore, they did not put a second wire; but in all large towns, on all telegraph poles where there were other circuits, and in all cases where a second telephone circuit ran they invariably made a metallic circuit. Why the telephone people had not done so in all cases they must answer for themselves.

The Committee then adjourned.

TUESDAY, JUNE 20TH.

Mr. WM. E. L. GAINE (General Manager of the National Telephone Company) was the first witness. In reply to Mr. PEMBER, Q.C., he stated that the licence from the Post Office, under which the Company worked, dated from November 29, 1884, and was for 31 years, so that it would expire in December, 1912. It extended through the whole of the United Kingdom. The estimated annual number of calls was 109,339,220; the estimated number of messages 218,673,440; the annual value of exchange revenue and fees at April 30th was £554,171; the average cost per message was 0·608 of a penny; the total number of exchanges on April 30th, 506; the number of exchange and private lines, 60,155; and the total mileage of wires at the same date, 90,746. The estimated yearly number of messages between Manchester and Liverpool was 295,200, at an average cost of 3d. per message; Newcastle and Sunderland, 233,472, at 1·27d.; Leeds and Bradford, 189,696, at 1·14d.; Edinburgh and Glasgow, 108,552, at 2·65d.; London and Liverpool, 48,024, at 1s. 5·57d. The whole of the exchanges, with one or two exceptions, had been built up on the earth-circuit system, which was adopted in nearly every country—the United States, France, Germany, and others. The largest telephone system in any one town was that of Berlin, with 17,000 subscribers, which was entirely on the earth-circuit system. It was in the hands of the German Government. The earth circuit was amply sufficient for all commercial purposes where they had a local exchange to deal with, *i.e.*, where they could concentrate all their subscribers into one central exchange; if subscribers desired to use the long trunk wires, then they must have something suitable for that particular service. He did not suggest that the earth-circuit principle would meet the case of the subscriber who desired to have daily communication between London and Liverpool. The plan of the National Telephone Company was to adopt that system which was most suitable for the service required. If a man in Liverpool desired to have communication with a man in London he was put on to a metallic circuit at the Liverpool end, had the best instruments for long-distance speaking, and was charged a reasonable price. If a man desired to talk only with his neighbours and correspondents in Liverpool, then he did not require the same expensive service, and the earth circuit gave, as a matter of fact, an efficient and a good service.

The CHAIRMAN: Does that apply to Manchester?—Manchester and Liverpool, but I should not like to carry it much farther than that. There were conditions under which metallic circuits were essential, and metallic circuits were, at any rate, a considerable aid to giving an efficient service. In the case of London it had been somewhat notorious that as the system had rapidly developed on an earth-circuit principle, it did not give a service which the public were entitled to look for, and the National Telephone Company had had to look about them, and they had spent huge sums of money in the past few years in order to put first of all the junction wires between their London exchanges upon metallic circuits. They were now carrying that to its logical conclusion, and putting the whole of the subscribers in London on a metallic circuit. They had an area in what was known as London of 5,000 square miles, containing no less than 23 exchanges. Where they could concentrate their subscribers into one exchange, then, for local purposes, the single wire was sufficient; but with an area like London, where subscribers had constantly to pass through two and three exchanges to communicate with one another, then a metallic circuit was an aid to efficient service. In Liverpool they had between 3,000 and 4,000 subscribers concentrated in the central Liverpool exchange, and he did not hesitate to say they were giving them a thoroughly efficient and thoroughly good service.

Mr. PEMBER: At a low rate?—Yes, they had a large number of subscribers in Liverpool who paid an enhanced price because they wanted something better than the local service. They had about 3,500 wires, all concentrating overhead into the Liverpool central exchange.

Supposing that electric traction of a similar character to that which is employed on the tramway at Leeds were sanctioned and used on the Liverpool tramways, would all these lines of wires be so disturbed that you would have to turn them into metallic circuits?—Judging from the experience the Company had at Leeds, undoubtedly that would be so; those lines would be valueless for commercial purposes. I am particularly anxious to impress my views with regard to this on the Committee; Mr. Preece, in his evidence yesterday, was very strong as it appeared to me that the remedy of the Telephone Company was to duplicate their wires, but I doubt whether Mr. Preece, or anybody else, realised what that meant. This system has been built up for a number of years, and their 3,500 or 4,000 wires coming into the Liverpool Exchange had to come in all over the roofs, for which switchboards, &c., have been put up. The great bulk of the switchboards of the country were single boards; it meant the taking out of those, an enormous work, and the re-erecting of the entire system, and he had no hesitation in saying that if the Leeds tramway were planted in the City of Liverpool to-morrow Liverpool would be deprived of the telephone for at least five or six years. He would not undertake to re-duplicate the wires and re-arrange that system under that time.

You have said nothing of the enormous cost; those switch-boards are very expensive, are they not?—A switch-board for an exchange the size of the Liverpool exchange would not be less than £20,000. That, of course, did not take into account the cost of wayleaves, and ordinary repairs and maintenance. The National Telephone Company had periodical returns taken of calls upon the principal exchanges, and the number of calls in one day on the Central Exchange in Liverpool was no less than upwards of 44,000. Calculating a call between one subscriber and another as equal to two telegrams, they had thus 88,000 telegrams in one day, and it might be easily seen how great the deprivation of this means of communication would be to the commercial community of Liverpool, and, undoubtedly, they would be deprived of it, and for a long period. The Leeds tramway ran through one of the outskirts of Leeds, and it disturbed, comparatively speaking, only a few lines—26 lines. They brought an action against the lessees of the tramway to see if they had a right to some legal protection at common law; the decision of the Court being against them they had to find their own remedy. Although they had only 26 lines disturbed in Leeds, the cost of putting them on to a small extra exchange was between £600 and £700. If this were carried out to its logical conclusion, and assuming that the traction were to be universal all over the country, he estimated that it would cost the Company not very far from two millions of money.

In answer to Mr. CRIPPS, Q.C., who cross-examined on behalf of the electric traction interest, witness said Newcastle and Hull were examples of exchanges on metallic circuits. In those cases they charged a rent of £10 per annum to subscribers. In Liverpool also the rent was £10.

When you were working London on the earth system, what was the rental?—£17 upon a five years' contract, and £20 on one year's contract.

Then you have not charged more where you have the metallic circuit return than where you have an earth circuit return?—That is so.

Suppose in any district you had electric traction without perfect insulation, would not you say that a metallic circuit would be the best, and perhaps the only complete protection of the telephone?—I should say complete protection would be afforded by perfect insulation of the traction. He had no hesitation in saying that if all their system were put on to metallic circuits, and there were no question of time, convenience, or cost, and that the reasonable precautions were taken by the tramway traction, probably there would be no disturbance. Asked if he thought there was any practicable method by which electric traction and telephones might be used in reasonable contiguity except by putting the telephones on the metallic circuits, witness said he should prefer that an electrician should answer that. In London the alterations had extended for practical purposes to the whole of the junction wire on the different exchanges, and some proportion of subscribers' wires had been replaced by cables, but a very considerable cost had yet to be met in the alteration of the switch-boards. He could not give the cost up to the present time in really reliable figures, but he should think it was about £100,000.

Was the alteration made in London in order to improve your system because the earth system is not sufficiently efficient?—Probably, under the conditions existing in London, yes.

You said the earth system was in use on the Continent and in America. Take Paris, for instance?—I said generally; in Paris it is an entirely underground system. The charges on the metallic circuit in Paris, to the best of his belief, were £16 a-year rental, in addition to which subscribers had to find their own instruments.

And how does that compare with the £20 paid in London for the earth system?—The £16, plus the cost of the instruments, which makes it £17 (say), should be compared with the £17 a-year for a five years' contract in London. The French Government, however, had nothing in the way of wayleave to pay, whereas in London they had to pay many thousands a year. Overhead wires were very much cheaper initially, but very much more costly in their maintenance. They had about the same number of subscribers in Paris as they had in London; a trifle more, perhaps.

But there is a smaller population there?—Yes.

So that you give a better system on the same or better terms to a larger number of subscribers, in proportion to the population, in Paris than in London. Does not that suggest to you that by giving the better article—a metallic system—you get a larger number of subscribers, and can work the system cheaper?—No, I do not think so. The answer to that is, compare Paris with Berlin, where you have nearly double the number on a single-wire system. There was no doubt that as the service had grown up in London the earth system had not given so much satisfaction as the subscribers were entitled to; but London, telephonically, was an entirely different problem to any other place in the world; there was no place where there was so enormous an area and so great a population, which, of course, necessitated a great number of exchanges.

Surely the extent and population ought to make London the cheapest place in the world?—It is not concentrated telephonically.

Up to the present time you have had a large number of these special clauses; are you aware that wherever you have these clauses it is impossible to have electric traction?—I am not aware of that; on the contrary, I should like to say that in South Staffordshire a tramway company is running to-day, and is running subject to those clauses.

Can you give any other instance?—I am not aware of any.

You stated, I think rather widely, that in the United States, on the Continent, and everywhere else, the general system was the earth-return system; is not the metallic-circuit system very largely used in America?—For all very long distances it is the same as it is in this country. In America they have a principle of working what they call first, second, and third class; if a man desires to have long-distance telephony, or even telephony for a moderate distance, he goes on to first class, and has metallic circuits and the best instruments, for which the charge in New York, I believe, is £40 per annum.

In answer to Mr. BALFOUR BROWNE, Q.C., witness said he had no idea what the mileage of tramways in this country was. He admitted that

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every tramway must be laid down either under an Act of Parliament or a Provisional Order, whereas the tenure of their telephone lines was only by license of the proprietors of the houses over which the lines were laid, and, unfortunately, was generally limited to three months. He believed tramways were being worked by electricity in Walsall. Asked if this did not harm their telephones, witness said there had been some complaints. He had heard they were working there under a protective clause.

Are you aware that the Corporation of Walsall said they would rather give up the telephone than the electric traction?—No, I am not; so far as I know no application has been made to the Corporation. Asked the same question with regard to Blackpool, he thought very likely it might be so in that case, because, to a sea-side town like that an electric tramway along the sea shore was an attraction, and there was also a comparatively limited number of subscribers. In further cross-examination, witness submitted to the Committee that the National Telephone Company were really performing, under license from the Postmaster-General, a part of the service of the State, and paid the State on their present annual revenue something like £55.000 per annum. There was no provision in their licence as to the charges which they were to make to the public, similar to the clauses in the Tramway Acts, simply because they had no corresponding powers to run their wires. He was aware that the Postmaster-General had given public notice that no further licence would be granted to any telephone company without the use of a metallic circuit.

Continuing, the WITNESS said that the New Telephone Company started with the intention of always having metallic returns, and charged at first £12. 12s., as against the present charge by the National Company of £20. The total mileage of the Companies' wire was 90.000 miles. The New Telephone Company did not start as the Mutual at Manchester, but the Mutual started as a separate undertaking, and the New Telephone Company subsequently acquired it. The price charged by the Mutual was lower than that of the National. The capital of the National Company was £4.000,000, but he could not say how much of that had been expended.

Mr. BALFOUR BROWNE: The New Telephone Company was not amalgamated with you, I believe, but all their shares were bought up by you at a premium?—Not all the shares.

Most of them?—A large proportion. They were bought at £5 a share, on which £4 was paid.

Is there a single company which has been started with a licence that your Company has not bought up?—I explained to the Committee that the whole of the licences were practically held by our Company, and that the whole service was done by the National Telephone Company. I think we have bought up 13 different licences. He could not say what was the length of the Company's wires in the administrative county of London, but it was more than 6,000 miles. He could not tell the amount of capital which had been expended upon them. His estimate for making a complete change from earth returns into metallic returns in London would be about a quarter of a million sterling.

By Mr PEMBER: He could not say whether the Parisian telephone system, which belonged to the Government, was worked at a profit or loss. There would be nothing in the accounts of the Government equivalent to the royalty which the National Company paid to the English Government, which amounted to £55,000 per annum, being 10 per cent. on the gross receipts from the exchange business. On the net receipts, of course, it would work out at much more. He was not very conversant with the Vienna telephones; there was a company, he knew, but he thought the State had acquired most of the services. He did not know if the system was as good as at Paris. At Berlin the telephones belonged to the Government, and were worked entirely on the single-wire system with an earth return. The number of subscribers at Berlin was larger in proportion than in Paris, and larger, he thought, than in any other town in the world. The South Staffordshire Company, the City and South London, and the Liverpool Overhead Railway, were instances of companies which worked under the Plymouth Clause, and the Blackpool Corporation had just elected to put the same clause into their Order this year. In the action against the Leeds Tramway Company, a list of the towns in which the Post Office competed with the Company was put in which showed that they had 1,325 subscribers in the country. He was not very well able to say whether the Post Office business was a growing one or the reverse.

By the CHAIRMAN: A large amount had been spent by the Company during the last two years in altering the service, and though there had been consequently some disturbance of the system there had been no electrical disturbance. The great difficulty was that when they sent a man on to the roofs to attend to the wires the wires came in contact, and it led to a great deal of disturbance.

The CHAIRMAN: I did not understand why you said you could not alter your system at Liverpool without stopping altogether for five or six years?—If the railway were worked it would disturb us so as to make our system unworkable. We can go on altering the system and carry on business at the same time.

By Mr. FORWOOD: If the tramways were to be worked by electricity they would want four or five years' notice of it. The underground system was more economical in maintenance, but it did not give so efficient a service telephonically as an overhead wire. There was nothing so good as an overhead wire.

In your judgment a metallic circuit is better than the earth?—For long distances, certainly not for local service. That is the whole point I endeavoured to impress upon the Committee.

Have you had any experience of subscribers in London complaining of disturbance, say, between Whitehall and the City, and have you recommended the putting up of a metallic circuit at an extra cost?—There may have been individual cases of that kind. If the Committee could see one of the switchboards they would realise the fact that they could not deal with many of such cases unless they took the whole thing out, and put them all on one system. The reason for the recommendation was that they were giving here two exchanges, and where they had that condition of affairs, he said at once that a metallic circuit was an aid to good work. There was at present a metallic circuit from the City to the House of Commons.

By Mr. MOLLOY: The cost up to the present of converting the earth system in London into the metallic system had been about £100.000, and before it was completed it would cost a quarter of a million. In London, where they had extraordinary complications to deal with, the metallic system was the best for good work; but in Liverpool, where there was concentration, it was not the best for telephony for local purposes.

By Lord CLIFFORD: In putting up a new system, the difference in cost between metallic and earth returns would be that the former would cost a third or half as much again. As to the cost of maintenance, the only estimate he had given was as between underground and overhead wires.

By Sir BERNHARD SAMUELSON: The circumstances which led to the placing of the wires underground at Newcastle were that the Corporation did not like overhead wires, and gave cheap facilities for putting them underground. The reason that they were placed underground in Hull was on account of the town being dominated by the docks, and it was thought by the engineer better to have them underground than overhead. The Company's patent was for 34 years, and expired in 1912.

Dr. JOHN HOPKINSON, F.R.S., examined by Mr. WALLACE, said that as regards the comparative cost of the earth's circuit and the metallic circuit, it was pretty obvious that for materials the cost of the metallic return would be double, but there would be some items (for example, the poles and the cost of erecting the poles) which would not be increased in that ratio. If the rights of taking up the streets were given to the Company, a great deal would be saved by putting the wires underground, especially as they would be freed from the payment of way-leaves. If the work of the electric lighting companies was properly carried out it constituted no detriment to the telephone companies as at present wired, because the electric lighting companies were bound to insulate their whole system.

Would a tramway company affect the telephone to any greater extent than an electric lighting company?—If electric lighting companies were to get their leads to earth at both ends it would be, broadly speaking, the same. There would be disturbing influences arising from contacts with the tramcar. He made an inspection of the Leeds tramway in 1891. He also went into the Leeds telephone exchange, which was on the single-wire system, and on using the telephone he heard a noise which would rise and fall at a varying pitch, so that it was impossible to converse with any distinctness. He could hear the cars stop, and could hear distinctly that there were two cars running by the difference in the pitch of the note. The sound diminished in loudness as the cars took a larger or smaller current. When the cars stopped there was practically no disturbance.

In your opinion was that noise such as would prevent the proper working of a telephone exchange on the single-wire system?—Yes, undoubtedly it was. He had had an experience of telephone exchanges worked on the single-wire system where there was no electrical tramway, and found that there was no disturbance. In London the system was now sufficiently good for all practical purposes. It had much improved in the last three or four years, and the improvement was still going on. With regard to the cost to the traction companies of making returns to the station isolated, he said there were many ways in which the tramway company could convey their currents for the purpose of driving their cars. The system of overhead conductors was most largely employed. In that case no doubt, a certain slight additional complication would be introduced in using two conductors overhead instead of one, but, on the other hand, some advantages would result from doing it. The pressure at which the cars could be driven would be double, because the danger to the public arises results from the difference of that pressure from the earth pressure. Being thus able to work at double pressure, they could work with half the current as measured in amperes. If they were allowed to use the double pressure they would diminish the capital outlay, and also diminish the running charges. He had not seen a double-trolley overhead system of tramcars; but at Vevey he had seen an arrangement with double wires, in which the overhead conductors formed a tube, and the conductor went alongside the tube. With regard to double tramways underground, he went to Buda Pesth for the express purpose of seeing how the system was carried out there, and whether it disturbed the telephones. There were 22 kilometres of single line; but as the line was almost all double, that represented about 11 kilometres of double line. The conductors throughout were laid out underground. The conductor was carried underneath the rail at the side. The railway was constructed by Messrs. Siemens and Halske. Underneath the rail was a culvert, and in that culvert were two conductors of angle iron carried upon insulators. The culvert was formed of castings, and was made up, between those castings, of concrete and brick. Both those conductors were insulated. He inquired especially of the telephone authorities in Buda Pesth whether there had been any disturbance upon their telephones from the tramways, their system of conductors being entirely by earth return. He listened on the telephones, and heard no disturbance. He could detect absolutely nothing. He travelled upon the tramways the same day, and supposed that there were between 50 and 60 cars running at the time. The insulator on each of the cast-iron formers which carried the rails, and the angle iron which conveyed the current, was attached to the insulator which was produced for the express purpose of insulating the angle iron. He had no doubt that such a system as that could be worked so as to pay the shareholders. The only disadvantage that he noticed was that the slot in the rail was about 1¼in. in width. If he were doing the work himself, he should not use so wide a slot as that, but only ¾in. wide. All that he would have to do would be to carry the little instrument which made contact with the two conductors through the slot.

Mr. MOLLOY: In this Buda Pesth tramway is there any earthing except it may be accidental leakage?—No, both sides were perfectly

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insulated, and the engineer had to keep it perfectly insulated at all times.

By Mr. WALLACE: In addition to the forms of traction of which he had spoken, of course there was the system with accumulators which had been tried in America with great success from an engineering point of view undoubtedly, but had hitherto been very costly.

In reply to Mr. MOON (on behalf of the railway companies), the witness described the system of block signalling, in which he said the current used did not exceed an ampere, but probably would be less, the voltage being three or four volts, representing only a normal telegraph current; the leakage of such electricity as was used for traction would be sufficient to operate the signals. If there were favourable circumstances, such as gas or water pipes, in the direction of the signals, the effect of the leakage would be felt at a greater distance. He had seen the arrangement of signalling at Blackpool, and observed the experiment as to how far the tramway current disturbed the electric signal. He heard the bell ring twice, and the signal was pulled down from safety to danger twice, without any intentional action on the part of the signalmen.

Mr. MOON: I do not need to ask any such obvious question as to what the effect of that would be, but the signalman would have no means of knowing whether it had been operated upon by one of these vagrant earth currents, or whether it had been operated from the next box?—No; none. In his opinion the remedy for that state of things was the insulation of the return currents in the case of the electric tramways.

By Mr. WALLACE: With regard to the currents sent to earth by the telephone company and the tramway company, there was a considerable difference in the electrolytic action upon the pipes and metals in the street. The effects and currents from electric lighting on gas and water pipes was becoming a matter of common observation both in this country and America. The pipes got oxidised, and there was very serious danger arising from it. On the other hand, from the telephones it would take 50,000 years to oxidise. It was probable that signals were altered by natural electrical force like lightning. He did not know that the Caledonian Railway Company had made an absolute metallic return between their signal boxes in every case; although in electric lighting no earth current was allowed, occasionally there was unavoided leakage—he would not say unavoidable leakage. If there was a material leakage, say 1-200th or 1-300th of an ampere it ought to be cut off from the system at once. The Board of Trade put the companies under obligation to cut off any consumer whose leakage was less than 1 5,000th ohm. Induction would be much more if the lines were parallel; for induction they must have a certain amount of parallelism in the wires. The Southend system was not precisely the same as that at Leeds, as at the former place they had an insulated return by the rails. The cost of the Buda Pesth system was about £4,000 per statute mile, which, of course, included the rails.

Mr. BALFOUR BROWNE: Supposing two things to be coincident—a tramway to be made and a telephone to be laid—would not much the cheapest method be to double your wires in the twist? I should say not. It depends on the scale on which the work is carried out.

Do not you think, even without tramways, that is what the telephones are coming to?—In London special conditions apply. If they could get the right of taking up the streets and laying the conductors underground, I have no doubt they would rather face any cost there may be, rather than have the cost of maintaining overhead conductors and the cost of wayleaves.

Mr. CRIPPS: Which do you get a greater disturbance from, leakage or induction?—From induction, I should say. If electric tramways were working in a town, they could not entirely eliminate the disturbance so long as they had earth connection on any part of the telephone system there.

Mr. POPE, Q.C., here asked leave to make an application on behalf of the gas companies. Since yesterday, in consequence of an answer given by Mr. Preece as to the connection of the gas pipes and water pipes with the conductors, the gas companies had become very considerably alarmed, and more especially because they had found that, in the case of Blackpool, the use of the gas pipes as a link in the return circuit had been recommended, and actually adopted. The gas companies were not at the moment before the Committee, but they would very much desire to be, because they thought great danger was involved in the suggestion which had been made, and they would like the opportunity of giving some evidence with regard to the matter. It might be necessary that a petition should be presented to entitle them to appear. It would be a most dangerous thing if their pipes were made use of.

The CHAIRMAN: In Preston that was so.

Mr. POPE: Yes.

In answer to Mr. HANS HAMILTON, Dr. HOPKINSON said he did not advocate the use of accumulators as a commercial possibility. The question of a circuit return was largely a matter of expense, but there were other considerations. He objected to doubling the wires overhead.

Dr. EDWARD HOPKINSON, C.E., said his firm had supplied the plant for the City and South London Railway, as well as for tramways on the Continent and in the Colonies. He gave hypothetical estimates for various tramways with completely insulated returns.

Lord KELVIN, in answer to Mr. PEMBER, stated that he was intimately acquainted with the practical and scientific questions involved in the use of the electric telegraph, and that particular branch known as the telephone-exchange system. He was interested in the Telephone Company; but he hoped he did not give evidence as a partisan, as he thought he could disassociate any interest he had in the Company from questions of fact. From the first it had been the practice to work the electric telegraph by the earth-return system. It had been seriously interfered with in a few cases by external disturbing causes. He knew of a case in Glasgow, where a disturbance of the telephone lines was caused by the running of trains lighted by electricity. The trains ran through a tunnel, and the current was conveyed through a fixed rail and the lamps on the carriages

Can you distinguish at all between the currents used for electric lighting and those used for power in their effect upon telephones?—It would be very analogous in quantity and quality. The same current might be used at one time for lighting purposes, and at another for power; and he saw no reason why the restrictions imposed on one should not equally be imposed on the other. In the summer of last year he accompanied Sir Frederick Bramwell to Leeds to make an inspection of the tramway works there, and he examined carefully the lines, the system of conductors, the mode of carrying the electric current on to the cars, and the engines, dynamos, and instruments. He found that the return circuit was not insulated, and there was a very great disturbance on the neighbouring telephone lines. He attributed the disturbance partly to leakage and partly to induction.

I believe that tramway is worked by a direct current, is it not?—Yes, but the current continually alters. Multiplication of contacts on the car would diminish the disturbance. He thought the disturbance could be prevented by having two conductors and keeping the conductors of the tram-line wholly insulated.

Have you gone into the additional cost of putting an extra line?—I have not gone into it in detail. He had considered the alternative method of working these motors by accumulators; it was a method which had been practised in some cases with success, but whether ultimately it would be commercially satisfactory or not he could not say. In many respects it was to be preferred to insulated conductors. He was of opinion that no one could venture to pronounce in favour or against the use of accumulators in the future.

There is, of course, a counter suggestion that it would be possible for the telephone company to remedy the difficulty by ceasing to use the earth. What do you say as to that?—I think that anyone who passes through the City of London and looks overhead may see that it would be a very great evil to the public if the number of wires were doubled, and it would be necessary to double them to complete the metallic system.

Mr. CRIPPS: You said that the same obligation might be put upon the tramway companies as were put upon the electric lighting companies; would you not rather enlarge that and say that a similar obligation should be put upon the various companies, including the telephone company?—I think not. I think the telephone is so valuable a discovery that it should not be interfered with.

But the difficulty is that the Telephone Company being here no one else can use the earth, is it not?—It would not be disturbed by the Electric Lighting Company. The claim of the Telephone Company was to be allowed to continue the use of the earth as heretofore. He thought the use of the earth for both telephones and telegrams had been unlimited and undisturbed from about the year 1837; it would be a great inconvenience to the public to introduce metallic circuits for all telephones. The electric lighting companies used the gas pipes and water pipes, and if the same thing were done by the tramways, he believed those pipes would be very seriously affected. The telephonic communication was not disturbed by the City and South London Railway, which was not insulated: he admitted the circumstances were different, owing to that railway being enclosed in an iron tube. He did not think that he had expressed the view that there was any considerable practical difficulty in insulating a conductor so that there was no leakage. In the Clapham Junction and Paddington Bill he gave evidence as to the disturbance of the delicate scientific instruments at the laboratory at South Kensington, and the difficulty of maintaining the insulation. It would not be difficult to maintain it to such a degree as not to disturb the telephones, but very difficult to maintain it to such a degree as not to disturb delicate instruments within a short distance of the line of railway. He agreed with Dr. Hopkinson that induction was quite as deleterious to the telephones as leakage. Insulation would deal with the question of induction, because the two insulated conductors would be close side by side. If the metallic circuit consisted of a completely insulated circuit, of which the outgoing and incoming wires or conductors were far apart, there would be disturbance. If the two conductors were insulated side by side, within a few feet of one another, and worked as they would be worked on electric tramways, there would be no sensible disturbance at all upon telephonic lines. The insulation might be quite complete, and yet if there was a varying alternate current through the the system, the induction would be affected. He did not think there would be such disturbance caused by the tramways with two insulated wires side by side as would affect telephones or railway signals. For electric cables he would have the wires underground, but that was not the proper place for a telephone wire, because the telephone was vastly retarded and impeded by the induction which wires underground necessarily experienced. He ascribed the unsatisfactory nature of London telephone service to the great number of wires of all kinds and the great number of disturbances. If the air wires were duplicated it might make the speaking clearer and better for a time, but they would be more liable to interruption by a snow storm. In electric traction, the slot which would be necessary to enable the arm to get to the wire to pick up the electricity should be considerably less than an inch wide; still, it would be open enough for water to get down, but the insulation would not cease if it were kept free from water by proper draining out. Anything which made a connection between the conductor and the bottom of the culvert would bring about leakage. He did not know what the cost of providing an overhead system of insulation at Leeds would be.

In the Folkestone case you gave evidence, and I think you said that £40 a mile spent upon three miles of line, or £120 altogether, would completely insulate the conductors?—I do not remember that expression, but it is about right.

Do you know what was done in that case? The Committee said if the Telephone Company wants to have that insulated they should pay the £120 to have it done, or they should insulate it themselves. Do you know that that was the decision?—I do not know.

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Do you know that from that day to this the Telephone Company have never done it—they refused to take the order under the circumstances? I do not know.

By Mr. PEMBER: The Glasgow system worked very well as a whole. In the Clapham Junction and Paddington scheme there were several things that were to be feared—vibration and mechanical disturbance, as well as electric disturbance.

In reply to Lord CLIFFORD, who asked if in London there were any electric currents, natural or artificial, other than those created by tramways and electric lighting companies which would be sufficient to interfere with the telephones, Lord KELVIN said he thought the present telephone disturbance in London was chiefly due to the telegraphs, and was partly due to the telephone wires themselves. Any small amount of electricity used for ringing bells and so on would not affect them at all.

By Earl RUSSELL: The use of accumulators on electric launches on the Thames had given them a certain amount of experience, showing that it was not an absolutely impracticable system for tramways, but the cost was not a question with those who used the launches. He did not think any one had yet succeeded in bringing the cost of accumulators down sufficiently to allow of their use for tramways.

The CHAIRMAN said the Committee had considered the question that Mr. Pope had raised about the gas companies, and though he did not suppose they would want to cross-examine all the witnesses, he thought they should be heard in the matter, as they might wish to propose some kind of restriction, which would bring them within the terms of the reference. The case of the water companies was very much the same as that of the gas companies, and probably they could be represented by the same counsel.

Mr. POPE said he should think in all probability that would be so, but he was not instructed on behalf of the Water Companies.

The CHAIRMAN said the Committee thought their case was one, and, therefore, they must be represented by one counsel. They might call their own witnesses to say that they required to be protected in a particular manner.

The Committee then adjourned.

On Wednesday, Mr. Dane Sinclair (Engineer-in-Chief of the National Telephone Company), Sir Frederick Bramwell, Mr. Winterbotham (solicitor to the Company), Dr. Edward Hopkinson, C.E., and Mr. J. S. Forbes (Chairman of the National Telephone Company), gave evidence on behalf of the Telephone Company; and Mr. Aspinall, Engineer of the Lancashire and Yorkshire Railway Company, and Mr. Fletcher, principal Assistant-Engineer of the London and North-Western Railway Company, were examined on behalf of the railway interests.

On Thursday Mr. W. E. Langdon (Electrical Enginner to the Midland Railway Company) and Mr. Spagnoletti (Electrical Engineer of the Great Western Company) also gave evidence, and this closed the case for the Railway Companies; Mr. James Swinburne and Mr. R. E. Crompton were examined on behalf of the Electric Traction Companies.

[*The report will be continued in our next issue.*]

LEGAL INTELLIGENCE.

Elmore's French Patent Copper Depositing Company (Limited).

Three petitions in regard to this case came before Mr. Justice Vaughan Williams on Wednesday. Other proceedings in connection with the same Company had recently come before Mr. Justice Chitty, who had made an order in the matter, which had reference to a proposed arrangement in France, whereby the assets might be realised. Mr. Wilkinson and Mr. Swinfen Eady, who represented petitioning debenture-holders, now withdrew their petitions and acceded to an application by Mr. MacNaughton, representing the liquidators, that the further consideration of the compulsory winding-up petition should be deferred for a month.

Mr. EVE opposed this application on behalf of the unsecured creditors, who, he said, had hitherto received no consideration, and had no means of knowing the nature of the proposed arrangement. They considered that a further adjournment would act prejudicially to their interests unless some independent person were appointed to see that no arrangement was carried out which was not equitable. After some discussion between counsel,

His LORDSHIP suggested that the liquidators and debenture-holders should consent, in the event of his granting an adjournment, that no arrangement should be carried out until it had been brought before him. Unless they consented to that course, he should make the order for the compulsory winding-up at once. He would allow the matter to stand over until Saturday, when, unless some arrangement were agreed to whereby the unsecured creditors might be adequately represented and protected, he should make the order for the compulsory winding-up.

Fowler-Waring Cables Company v. General Steam Navigation Company.

Mr. JUSTICE COLLINS heard this case in the Queen's Bench Division on Wednesday. It was an action for damages for neglect or breach of contract in connection with the carriage and delivery of a drum of telegraph cable. The defendants delivered the goods to the consignee, but without the production of the bill of lading. The consignee had not paid the plaintiffs for the goods, and the latter, failing an attempt made by the defendants to recover possession of them, sued the General Steam Navigation Company for the value of them, £88. 6s. 4d.

After hearing the evidence, His LORDSHIP held that the defendants were liable for the loss sustained, and gave judgment for the plaintiffs for the value of the cable (£88. 6s. 4d.), with costs.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June* 10, 1893.

Long-Distance Transmission of Power.—American electrical engineers have finally awakened to the great possibilities of electrical power transmission, and this branch is now being taken up in earnest in the United States, following the same lines under which other branches of the electrical industry have been so highly developed. It has, no doubt, been noted that in America the energy of the electrical profession has been concentrated on one object at a time instead of being spread over a great amount of ground. Arc lighting, incandescent lighting, and street railways, have in turn thus been developed, and now force is being brought to bear on the transmission of power. With the exception of the Niagara Falls plant, which, however, can scarcely be considered an American project, no attempt has thus far been made to transmit power over great distances, but rather towards the transmission of a large amount of power over a short distance. There are a number of plants now being constructed to transmit from 1,000 to 3,500 H.P. over distances of from 10 to 40 miles. The General Electric Company has five of these now in course of erection, the largest transmission, 3,500 H.P., being over only 10 miles. In California a plant is now being installed for the transmission of 3,000 H.P., 20 miles, under the guarantee that it will meet the requirements for all varieties of power, and that the efficiency of transmission from generator axle to point of distribution will be at least 79 per cent.

High-pressure Alternators.—A single-phase alternating-current lighting plant of 4,000 volts has been in operation at Portland (Ore.), for several years, and no difficulty whatever has been found in running the generators continuously with this high voltage; and we understand that an order has recently been placed for some new generators for the same plant, to be wound for 6,000 volts. *A propos* of this, Prof. Crocker has in his laboratory a direct-current transformer of 5,000 volts having only 36 bars in the commutator, and is building a similar one for 10,000 volts. From these instances it would appear that the art of insulating for high voltages has considerably advanced.

CORRESPONDENCE.

MUTUAL ATTRACTION OF VACUUM TUBES.

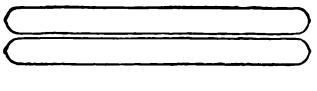
TO THE EDITOR OF THE ELECTRICIAN.

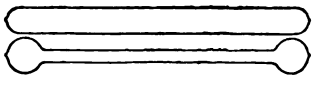
SIR: When trying some of the experiments shown the other evening at the Royal Society *soirée* by Mr. Pike and myself, I accidentally found that the attraction between two vacuum tubes far exceeded what theory would expect if due only to static effects, or to the mutual action of one current upon another.

Since that night I have been examining this question further. I have here only a limited supply of apparatus, so that my observations are of a general character, and not so complete as I hope to make them on my return to the country. To sum up the phenomena, which I maintain are truly magnetic, they are:—

1. Two vacuum tubes attract one another strongly.

2. The attraction is almost, if not quite, the same, whether they touch one another along the whole length, or only at their ends,

so: 

or so: 

(The upper tube in these experiments had the current induced in it by the lower tube.)

3. A spiral vacuum tube sucks in a "core" tube like a solenoid does an iron core, and the more the "core" is drawn

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in the less luminous the "core" tube appears. This lessening of luminosity might be expected. The core tube was not connected to the circuit.

4. When the tubes are placed end to end, so:

they attract one another and stick together; no repulsion takes place, which should occur if the effect were of a "static" nature. One tube *induced*.

5. No. 4 effect remains the same, no matter what positions are given to the tubes.

6. There are many other phenomena requiring further investigations; I, therefore, will not give incomplete and doubtful results.

I believe this subject is new, and if known already to anyone it has not come to light. Being a "bad hand" at producing Papers, for want of time, and perhaps capacity in this respect, leads me to write these few lines in the interest of workers in in the same direction as—Yours, &c.,

DAVID SALOMONS.

49, Grosvenor-street, W., June 15, 1893.

[These experiments cannot readily be explained, whether the phenomena are assumed to be magnetic or static. If the effect is static, the attracting force between the tubes might persist for a few moments after the current is switched off, and it would be interesting to test whether this is the case. Also it is desirable to know the actual magnitude of the force, referred to in experiment (1), with which the "tubes attract one another strongly."—ED. *E.*]

MR. DENNY LANE'S PRESIDENTIAL ADDRESS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On my return from Belfast I found your article in *The Electrician*. I have to thank you for the favourable terms in which you have spoken of my Address, but in placing me "above the majority of experienced electrical engineers," you have, I think, done them an injustice and attributed to me attainments which I do not yet possess; but which by practical work I may some day approach.

In comparing gas and electric light I endeavoured to hold the balance fairly, but I suppose none of us are free from prejudices. In attributing to gas power of three candles per foot, I calculated no more than can be got by a good Argand burner, without any juggling with temperatures. Such a burner will last for a dozen years or more. It is true that the chimney is sometimes broken, but a new one costs but a few pence against the high price of a new incandescent lamp.

With reference to flat-flame burners which give less light per foot, this deficiency is on the other side equalled by the blackening of glow lamps, and the rapid decline of light whenever the voltage falls, which is, I believe, 6 per cent. for less than 1 per cent. of voltage. Indeed, a fall of several volts reduces the filament to the condition of a red-hot knitting needle. This, of course, should not be the case, but where gas is debited with the carelessness of attendants, surely electricity shall not be held scot-free from the consequences of similar errors.

An old miser of Cologne heard that another miser of Frankfort was more parsimonious than himself, and in order to find out how this could be possible, went on foot to the latter to consult this past-master in niggardliness. He found the man of Frankfort totting his books by the glimmer of a rushlight. When the traveller told the object of his visit, his rival answered, "we can talk as well in the dark," and blew out the rushlight.

Now some of those people who talk of the economy of the electric light must certainly imitate the German miser. There are 1,800 hours in the year from dusk to 11 p.m., and when we hear of only 240 to 365 hours per lamp fixed, I am convinced the economists save their purses at the expense of their comfort. A contemporary scientific journal derides my Irish "figures of speech," but does not assail my figures of arithmetic, and says that Mr. Preece never meant what he said. Be that as it may, he meant other people to believe that current could be supplied at one-third of a penny, for he speaks distinctly of a *supply* unit, and not of a unit generated. If the true function of language be to conceal our thoughts Mr. Preece has admirably succeeded.

I may give as a specimen of the style of the opponents of gas the following paragraph from one of last week's technical journals:—"We contend that a bigger sanitary curse there cannot be than a half-turned-off gas jet. It is a stinking nuisance." Now this, I allege, is absolutely untrue. I have, besides experience extending further back, an intimate connection with gas lighting for 37 years, and I have never found any *lighting* burner, even when turned down to one-tenth of its usual consumption, emit any smell whatever. Of course, a badly-made, or badly-used, Bunsen burner used for heating purposes may "strike back" and produce a most unpleasant smell, but with some burners this is impossible, and with any only possible if the primary supply of air is too large in proportion to the supply of gas, so that the mixture of air and gas burns within the tube instead of doing so at the right place—the upper orifice.

I am no foe of electric light if it be good and fairly cheap; it is not within my feeble powers to make it bad or dear. It has its function, and an important one, to fulfil, but its position will not be advanced by the injudicious advocates who think they whiten their own industry by blackening the character of others whom they should regard as colleagues and not as enemies.

Instead of injuring the cause of electric light, I have done my best to serve it by showing that the cardinal difficulties of storage and distribution can be got over by the employment of sub-stations worked by gas engines. If in endeavouring to aid others, I also try to help myself, I am convinced that this is the form of benevolence which is most likely to be imitated.—Yours, &c.,

DENNY LANE.

72, South Mall, Cork, June 19, 1893.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The Electric Lighting Committee of the County Borough of Huddersfield require tenders for certain materials and labour requisite for laying an electric supply main. Further particulars are given elsewhere, and the specification and forms of tender may be obtained on application to Mr. A. B. Mountain, the borough electrical engineer, Gas Works, Huddersfield, and tenders must be sent in to him by Saturday, July 1st.

——— The City of Glasgow District Lunacy Board require tenders for installing the electric light at the Asylum Buildings at Gartloch. Tenders must be sent in to Mr. Dempster, 318, Parliamentary-road, Glasgow, by Monday, the 26th inst. The Board also require tenders for the supply and fitting up of three Lancashire boilers, for use in connection with the electric lighting. These tenders must also be sent in to Mr. Dempster by the 26th inst. Some further particulars will be found in our advertisement pages.

——— The Committee of the G.U.O.O.F. Central Club require tenders for lamps, wires, fittings, &c., and the fitting up of 82 electric lamps in their premises at Keighley Green, Burnley. Tenders must be in by the 27th inst.

TENDERS ACCEPTED.—The Ealing Local Board have accepted the tender of Messrs. Latimer Clark, Muirhead, and Co., for the erection of machinery in connection with the electric lighting scheme. The following is the complete list of tenders for machinery:—

Clark, Muirhead, and Co., London (accepted)	£7,440
Crompton and Co., London	7,460
Willans and Robinson, Thames Ditton	8,511
Siemens Bros. and Co., London	8,754
Ronald A. Scott, Acton	9,000
W. H. Allen and Co., London	9,300
Electric Construction Corporation, Wolverhampton	9,381
S. Z. de Ferranti, London	10,075
Johnson and Phillips, London	10,160
Woodhouse and Rawson United, London	10,300
Paterson and Cooper, London	10,160
W. T. Goolden and Co., London	10,881
Fowler and Co., Leeds	11,087
Paul Matthew and Co., Dumbarton	12,000

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APPOINTMENTS.—Mr. G. Roper, of the Board of Trade, has resigned the position of Secretary to the Royal Commission upon Electrical Communication between Lightships and the Shore, and is succeeded by Mr. E. G. Moggridge.

——— Mr. J. J. Walklate, of the South Staffordshire Tramways, and who was identified with the construction of the Walsall Tramways, has been appointed Resident Engineer to the Douglas and Laxey Electric Railway.

APPOINTMENTS VACANT.—The Town Council of Aberdeen advertise for applications for the post of Electrical Engineer to take the more immediate charge of the electric lighting department under the superintendence of the Corporation Gas Works. The salary will be £200 per annum. Further particulars will be found in our advertisement columns, and applications must be sent to Mr. W. Gordon, town clerk, by Friday, the 30th inst.

——— Applications for the appointment of Electrical Engineer at Kingston-upon-Hull have to be sent in to Mr. R. Hill Dawe, Town Clerk, Town Hall, by noon of Thursday next.

——— Applications for the appointment of Electrical Engineer to the Vestry of St. Mary, Islington, London, N., must be sent in to Mr. Wm. F. Dewey, Vestry Clerk, by Wednesday, July 5th.

BANKRUPTCY.—Duncan McGregor, carrying on business at Glasgow, Greenock, London, and Liverpool, under the title of D. McGregor and Co., chronometer and compass makers. A meeting for the election of trustee and commissioners is to be held at the Faculty Hall, Glasgow, on June 27th, at 12, and claims must be in by October 14th.——In the case of William McWhirter, Mr. J. C. Bowes has been elected trustee, and Messrs. A. Campbell, J. H. Carruthers, and J. A. Rudd commissioners. The bankrupt's examination is to be held at Sheriff Guthrie's chambers, Glasgow, to-day (Friday), at 12, and a meeting of creditors is to be held at Messrs. Nairn and Bowes's, 140, Hope-street, Glasgow, on July 3rd, at 2.

REMOVAL.—The International Okonite Company (Limited) have removed their registered offices from 98 and 100, Queen Victoria-street, to their works at Newton Heath, near Manchester. The London business will still be under the supervision of Mr. C. F. Quicke, for whom temporary offices have been taken at 38, Finsbury-pavement, London, E.C. The Okonite Company is undergoing reorganisation, and in the autumn the actual manufacture of okonite in this country will be commenced at their Manchester works In the interim opportunity will be taken for improving the machinery and processes for vulcanised rubber cable, which the Company continue to manufacture at Manchester.

PERSONAL.—Mr. A. G. Sanders, A.I.E.E., who has been on the staff of Messrs. Drake and Gorham for many years as engineer and in charge of the estimating department, has joined Messrs. B. Verity and Sons in a similar capacity in their Manchester business.

LONDON AND LANCASHIRE ELECTRIC AND GENERAL ENGINEERING COMPANY (LIMITED).—This Company which, as previously notified, has recently come under the management of Mr. C. N. Russell, have just concluded several important installations; one at the Holborn Offices of the New York Mutual Life Assurance Company, Bolton Mansions Hotel, Earl's Court, and Lipton's Croydon stores. The British Paper Company have placed the lighting of their Frogmore Mill at Hemel Hempstead in this Company's hands for both arc and incandescent lighting. The mills are to be run night and day. The Company are also busily engaged with installations in different parts of the country, and are busy with their general engineering work, for which new plant has recently been put down.

MESSRS. LAING, WHARTON, AND DOWN.—This Company report that their new office at Manchester, which is under the management of Mr. E. P. Crowther, has in hand a large number of installations of the electric light, including one for the Rochdale Corporation Sanitary Manure Works, another for Messrs. Vickerman and Sons, Taylor Hill Mills, Huddersfield, and for many of the principal banking and business establishments in Manchester and district.

MESSRS. FELTEN AND GUILLEAUME. We have received from Messrs. W. F. Dennis and Co., the agents for the United Kingdom of this firm, their latest general price-list of wire, wire ropes, strand, barb fencing, &c., &c. A large variety of the well-known manufactures of the firm are illustrated, and the descriptions are in all cases accompanied by prices. The firm employs 2,600 hands at the works at Mülheim, and engines of 2,600 H.P. have been put down.

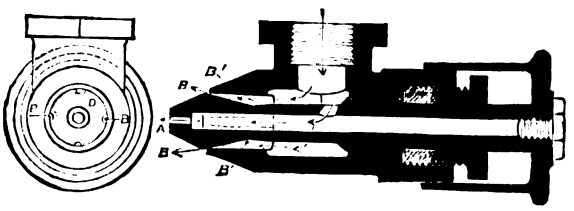
ELECTRICAL POWER STORAGE COMPANY (LIMITED).—This Company has just issued a handsome catalogue and price list of E.P.S. batteries and apparatus. The new list cancels all previous prices, and, in addition to giving complete descriptions and prices of the various types of E.P.S. cells, includes a number of tables which will be found of service to contractors and all persons contemplating the use of batteries in their lighting installations. The cost of the E.P.S. storage batteries, as our readers are aware, has been recently materially reduced, the reductions varying from 15 to 20 per cent. The discounts to the trade remain as before. Copies of the new list will be supplied to the trade on application to the Company's offices, 4, Great Winchester-street, London, E.C. The Company do not give details as to the maintenance of batteries, but offer to send one of their maintenance staff to make an inspection. They then quote a rate which varies between 5 and 15 per cent. We understand that the average rates for existing contracts are under 10 per cent. The rates are quoted as from the original date of supply of the batteries. We are informed that Prof. H. F. Weber, of Zurich, has tested the E.P.S. accumulators at the Union Bank, St. Gallen, which were supplied and erected in 1891, and has found a current efficiency of 97·5 per cent., and an energy efficiency of 82·4 per cent.

INTERNATIONAL ELECTRIC COMPANY.—In consequence of the growth of business, this Company announce that they have removed to more commodious premises at 155, Redcross-street, Barbican, London, E.C., where a larger stock of the Mix and Genest manufactures will be available. The electric light fittings department will be enlarged, and showrooms will be provided for Helios arc lamps, Phœnix carbons, electroliers, brackets, switches, cut-outs, &c. Some of the Company's specialities will be shown working.

BERLINER ELEKTROTECHNISCHE FABRIK (BAUER AND BETZ).—We have received from this firm a price list and particulars of the small electric motors manufactured by them for driving light machinery.

THE TELEPHONE IN AMERICA. It is said that at the present time there are 440,795 miles of wires used for telephone purposes, 552,720 telephones, and 232,140 subscribers to the exchanges, which provide employment for 9,970 persons.

GRANGER'S FORCED DRAUGHT FOR STEAM BOILERS.—The accompanying illustration shows one of the patent steam-and-air nozzles, manufactured by Mr. W. A. Granger, of London. The invention is intended to replace fans and blowers in the production of a forced furnace draught; and is arranged to supply a mixture of air



and steam below the grate, by injection through the nozzle into the ashpit, which is closed. By a special combination of a ring, B', with the ordinary nozzle shown at A and D, an annular orifice, B, is formed around the inner circular orifice; and a higher efficiency is obtained than with either plain annular or plain circular nozzles.

MACHINE TOOLS.—We have received a copy of the new (1893) catalogue, issued by Mr. Alfred Herbert, of Coventry, showing a large variety of machine tools manufactured by his firm. The catalogue contains 50 pages full of illustrations, descriptions, and prices. Firms requiring any description of machine tools should send for a copy of this catalogue.

THE ELECTRICAL INSTALLATION COMPANY.—We have received an attractive little pamphlet entitled "Electric Light and Power" from this Company. It describes the advantages of electric lighting, and gives hints on the arrangement of lamps and switches. A number of illustrations of fittings are given.

ELECTRIC LIGHT ILLUMINATIONS.—Mr. Shippey suggests that coloured glow lamps fixed to a lath may be whirled by a motor, to celebrate the forthcoming Royal Wedding. He informs us that this system has been patented, but that the patents have now expired.

ROYAL AGRICULTURAL SHOW, CHESTER.—This annual show was opened on Saturday last. Among the exhibitors were Messrs. Marshall, Sons and Co., Tangyes, Priestman Bros., Ransomes, Sims, and Jefferies, W. H. Bailey and Co., Crossley Bros., the Blackman Ventilating Company, Robey and Co., W. H. Willcox and Co., Isaac Dixon and Co., Ruston, Proctor, and Co., R. Hornsby and Sons, John Fowler and Co. (Leeds), and many others well known in the electrical and engineering industries. Messrs. Robey and Co. exhibit several of their well-known types of engines, specially suitable for electric lighting work, including a compound Robey engine and locomotive boiler combined, for mill and factory lighting, and a high-speed vertical engine, also specially constructed for electric lighting purposes. The gas and oil engines shown are of the latest design, with special arrangement for regulating speed. The latest type of portable oil engine works on the Otto cycle and is mounted on a strong steel cylindrical tank which

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contains the cooling water. A chamber containing a week's supply of oil is riveted under one end of the water tank, and the oil is pumped from this tank and forces the gas into an internal vaporiser, where it instantly becomes vapour, and is mixed with the due proportion of atmospheric air and expelled. Messrs. Priestman Bros. also exhibit their popular type of oil engine, varying from 2 to 20 H.P. One of these engines of 20 H.P. was shown driving a Mather and Platt dynamo. This engine has been selected by the United States, New South Wales, and Victorian Governments for electric lighting purposes. Messrs. Priestman Bros. selected the Royal Show for exhibiting the latest improvements in these oil engines, and since 1892 have further developed the marine type for launches, barges, &c., for which special advantages in propelling and reversing gear are claimed. Amongst the exhibits at Messrs. Carrick and Ritchie's stand were included a turbine with horizontal shaft connected direct to a dynamo, which the firm claim is admirably adapted for the lighting of country mansions where water-power is available.

ABERDEEN.—A meeting of the shareholders of the Northern Co-operative Company is to be called to consider the action of the Directors in regard to the electric lighting of the Company's central premises.

BEDFORD.—The Chairman of the Urban Sanitary Authority proposed at the last meeting that a special meeting of that body should be held on Wednesday last to discuss the electric lighting question. The request for tenders which were invited from companies or firms willing to undertake the responsibilities under the Provisional Order had resulted in applications from Mr. F. H. Medhurst, of Cambridge, who makes two propositions; (1) that the Order be transferred to himself; (2) that he undertakes for the sum of £24,000 the work of complete installation. Messrs. C. A. Parsons and Co. offer to put down a plant for £12,000, exclusive of buildings. With each of the above offers plans are enclosed showing the proposed area of lighting. The Bedford Electric Light Company (Limited) offer to undertake and carry out the Order. The Electric Light Sub-Committee, in their report to the meeting on Wednesday, notified their opinion that it would not be judicious to entrust a work of such importance to a private individual, and that Messrs. Parsons and Co.'s proposition does not comply with the terms of the advertisement, and that, therefore, the offer of the Bedford Electric Light Company is the only one they can recommend the authority to entertain.

BERLIN.—The Kaiser has granted his sanction to a proposal of Messrs. Siemens and Halske to construct an elevated electric railway in the southern portion of this city. The line, which is to be of ordinary gauge, is to be completed during 1894. Negotiations are in progress with the view of adopting electric traction as the motive power on the tramway system of Potsdam, near Berlin. The electric tramway between Breslau, Grabschen, and Morgenau recently commenced working.

BIRMINGHAM.—In the autumn of last year the Birmingham Electric Supply Company gave notice to the Corporation of their intention to apply for a Provisional Order extending their system to Edgbaston, and the City Council decided to withhold its consent to such powers being granted until such time as the general question of lighting the Borough by the Corporation itself had received attention. The Company, therefore, withdrew their application, and the Council have had the subject under their consideration, and we understand the result to be that the Corporation will be urged to undertake the supply themselves. In the meantime negotiations are in progress with the Directors of the local Supply Company, and it is not unlikely that certain conditions laid down by the Corporation will be accepted, which may lead the Corporation to postpone taking any steps for the present.

BLACKPOOL.—By the Blackpool, St. Anne's, and Lytham Tramways Bill, which came before the Committee of the House of Commons on Unopposed Bills last week, it is proposed that the Company who are to work the tramway shall be empowered to connect with those already within the area of the Blackpool Corporation, whose tramway is worked by electricity. The tramway is to be eight miles long, and power is included in the Bill to work it either by electricity or animal power. The promoters of the Bill have come to an agreement with the Corporation, and the lease with that body is scheduled in the Act. Clauses are inserted for the protection of the National Telephone Company, and these clauses have been agreed to by that Company. The preamble of the Bill was declared approved.

BOLTON.—The Gas Committee of the Corporation have approved the report of the Electric Lighting Committee upon the electric lighting scheme, and the architect's plans for the generating station have also been approved, and specifications are to be prepared and advertised for.

BREWERY LIGHTING.—The electric lighting of the Ajax Brewery, Richmond (Surrey) has been secured by Messrs. Tickner and Partington. Incandescents will be used for the inner illumination of the buildings, and arcs for the courtyard and roof.

BRIGHTON.—Lord Morley's Committee has passed the Brighton and Rottingdean Seashore Electric Railway Bill, which will now come up for confirmation by the House.

BRUSSELS.—The Brussels Local Administration invites requests for the supply of electric current, the work on the central station having sufficiently advanced to justify the expectation that current can be supplied early in the autumn. A charge of 10 centimes per 100 watts is to be the basis of the charge to be made for the current, with a discount of 5 per cent. upon all lamps which have burnt 1,000 hours per annum. The three-wire system will be adopted.

CANTERBURY.—A letter has been received from the Board of Trade with reference to the proposed transfer of the Electric Lighting Order, to which the Board propose making considerable alterations.

CITY OF LONDON.—On Monday the Committee on Unopposed Bills in the House of Lords passed the City of London Electric Lighting Bill, which authorises the amalgamation of the various undertakings having charge of the electric lighting of the City.—The City Lands Committee will shortly ask leave to extend the electric lighting of the Guildhall to the Museum at an estimated cost of £360.

DEWSBURY.—The Board of Guardians have instructed Mr. Peace, Clerk to the Guardians, to obtain a rough estimate of the cost of fitting up an electrical installation at the Workhouse.

DOUGLAS (ISLE OF MAN).—The Douglas and Laxey Electric Railway is being rapidly pushed forward with a view of a section being opened before the close of the present holiday season. It is constructed on the overhead-wire system; and the contractors for the work are Messrs. Mather and Platt.

EAST LONDON (SOUTH AFRICA).—Tenders have recently been invited for lighting the town of East London by electricity.

GALASHIELS.—The Law and Finance Committee of the Town Council have under consideration a letter from Mr. A. E. Browning, of Edinburgh, with regard to his intention to introduce the electric light into Galashiels.

HOWRAH (INDIA).—The Municipal Commissioners have sanctioned the introduction of the electric light into the principal streets and thoroughfares, and have agreed to allow Messrs. Martin and Co., the contractors, 55 rupees per lamp. This consent is only tentative, and will require renewal after four months.

IRISH LIGHTS.—In the House of Commons on Monday Mr. W. Kenny asked for information as to the application of the electric light as a fixed light at the Old Head of Kinsale, and whether the Board of Trade and the Trinity House had sanctioned the installation of the light. Mr. Kenny further asked that instructions should be given that nothing be done to introduce the electric light until a trial of Mr. Wigham's new gaslight had been completed. Mr. Mundella, in reply, stated that both the Trinity House and the Board of Trade had withheld their sanction to the introduction of the electric light, but that the question of Mr. Wigham's new gas-light trial rested with the Commissioners of Irish Lights.

ISLINGTON (LONDON, N.).—A Bill entrusting the electric lighting of Islington to the Vestry passed the Standing Orders of the House of Commons on Monday last.

LECTURES.—Sir Douglas Galton delivered a lecture on ventilating, heating, and lighting, in the Technical School, Kevin-street, Dublin, on Saturday last. A large number of students were present, and the lecture was a complete success.—On Monday last week a lecture upon "Electro-Medical Eccentricities," illustrated by experiments, was delivered at the Grand Concert Hall, West-street, Brighton, by Mr. H. Newman Lawrence, M.I.E.E.

MADRAS.—As stated in our last issue, the Directors of the Madras Electric Tramways Company have decided to adopt the conduit system, *vice* overhead wires. A system has been devised which, for a slight percentage over the sum required for the overhead system, will provide a mode of traction superior to the latter, especially in being less liable to short-circuiting. The drawings of this system have been received by the Chief Engineer in Madras, and Mr. Faulconer is preparing his plans for the approval of the Municipality and the Local Government. The conduit includes a cast-iron frame about 18in. to 20in. deep on the inside, and about 6in. thick; one of these is placed at intervals of 4ft.; the conductor is pendant from the top of the frame, and by an ingenious arrangement is brought into contact with the grooved trolly which is in direct communication with the wheel-motors. The conductor is so placed that it cannot be tampered with from the outside. Should the conduit require to be opened the removal of a few inches of surface macadam allows of an iron covering to be lifted in sections of 4ft. Square iron gratings at 8ft. intervals permit of the insulators

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being easily reached by the hand at any time. The conduit is made large enough to allow of lighting and additional power cables being placed within it. By the side of the conduit, between the rails, will be laid either a copper or steel wire conductor, connected at every 4ft. with the rails and with the iron casing of the conductor.

MANCHESTER.—Messrs. Drake and Gorham have received instructions to install the electric light throughout the Manchester and Salford Savings Bank. Incandescents of from 8 to 50 c.p. will be used. The generating plant consists of a 6 H.P. Otto gas engine and a dynamo manufactured by the Electric Construction Corporation, and included in the installation will be a battery of D.P. accumulators, capable of supplying 60 16 c.p. lamps for nine hours.

NANTWICH.—The Local Board have recently discussed the question of adopting the electric light.

NEWTOWN (WALES).—The Local Board have received a letter from Messrs. Rooper and Tozer, suggesting that the electric light be introduced into Newtown. Permission has been granted to the firm to prepare a report on condition that no expense be incurred by the Board for this purpose.

NOTTINGHAM.—There is to be an Exhibition held at Nottingham shortly, and the Victoria Hall is to be lighted throughout by electricity, the plant to be supplied by Messrs. Defries, and the motive-power by the Trent Gas Engine Company, of New Basford.

PLYMOUTH.—Last week the Bill confirming the Provisional Order of the Board of Trade, giving authority to the Plymouth Corporation to construct a series of tramways in development and extension of the present system through the principal thoroughfares of the district, came before the Parliamentary Select Committee on Unopposed Bills. The gauge is to be 3ft. 6in., and the motive-power may be either animal, steam, mechanical, or electrical. The Corporation has power to borrow £24,000, to be repaid in 30 years, the proceeds to be devoted to the construction of the tramways. The Bill was ordered to be reported to the House.

POPLAR.—Royal assent has been given to the Poplar Electric Lighting Act, and the District Board of Works are now in a position to introduce electricity for lighting and power purposes. The matter is under the discussion of the Works Committee.

RICHMOND (SURREY).—The Electric Lighting Committee have recommended the Town Council to accept the resignation of Mr. Shoolbred, C.E., as professional adviser.

SUNDERLAND.—The Highways Committee of the Town Council have received a report from Prof. Kennedy respecting the electric lighting of the town, and have submitted this to the Council with a recommendation that it be adopted, and that Prof. Kennedy be instructed to prepare detailed plans and estimates for the carrying out of the scheme. Alderman Bell urged that no time should be lost in this matter, as their Provisional Order will shortly expire. He was anxious that private persons should be prevented from obtaining powers to supply the light. Prof. Kennedy estimates the cost of providing the necessary plant, &c., for the public installation at £17,000, exclusive of the cost of land, which the Corporation already have at their disposal. The estimate was for a low-tension system, and if it was decided to extend the lighting to Monkwearmouth, an extra expense of £3,500 would be incurred for high tension. With a probable demand equal to 5,600 8 c.p. lamps no loss would result to the Corporation.

SUTTON (SURREY).—The Local Board have received three letters from engineers with regard to the electric lighting of the town, but the General Purposes Committee have deferred making any recommendation on that subject for the present.

SWEDEN.—The Swedish Government appears to be engaged in a not too successful rivalry with the local Telephone Company. When the Government recently determined to undertake an extension of telephonic connection, it was notoriously urged to this course by the fact that unless action was taken by the Government the spirited competition of the Stockholm Telephone Company would result in serious damage to the State Telegraphs. The Stockholm Company is a wealthy body, and has about 7,000 subscribers to its system. The State Department has only about 1,600 subscribers.

TIVERTON.—Messrs. Ford and Son, brewers, are erecting a small station on the River Lowman for supplying their brewery and other premises with the electric light.

VIENNA.—A proposal by Messrs. Siemens and Halske to the Municipal Authorities to light several streets experimentally by electricity has been accepted.

WESTON-SUPER-MARE.—The Inspection Committee of the Town Commissioners have received a letter from the Brush Company offering to submit, free of charge, a scheme for the complete equipment of a central station at Weston, and to send a representative to discuss the matter. The Committee agreed to the suggestion, and a conference is to be arranged.

WORCESTER.—The Highways Committee of the County Council have resolved to conclude an agreement with the City of Worcester in regard to the laying of mains for the electric light from Powick to Worcester. It is essential that the sanction of the County Council should be given before the necessary loan for carrying out the electric lighting scheme could receive the sanction of the Local Government Board.

YARMOUTH.—A Local Government Board inquiry has been held here during the week in reference to the borrowing of £15,0000 by the Town Council for its electric lighting scheme. Considerable local interest is taken in the subject, and strong opposition is threatened. Mr. W. H. Preece, Junr., stated that it was proposed to use the high-tension system, and the light would be supplied to consumers at 6d. per unit. A number of prominent residents notified their intention of taking the light as soon as the Corporation were in a position to supply it.

COMPANIES' MEETINGS AND REPORTS.

Electric and General Investment Company (Limited.)

The following is the report of the Directors of this Company, for the year ended May 31st last, to be submitted to the Fourth Ordinary General Meeting to be held at Winchester House, E.C., on Tuesday next, at 3:30 o'clock :—

The Profit and Loss Account shows a gross profit on the transactions of the year of £11,092. 15s. 4d., and after deducting all standing charges there remains a net balance available for distribution of £6,065. 16s. 5d. An interim dividend has already been paid on the Ordinary Shares for the first six months of the year at the rate of 20 per cent. per annum, and the Directors now recommend the payment of a further dividend upon the Ordinary Shares at the rate of 30 per cent. per annum for the past six months, and a dividend on the Founders' shares of £30 per share. This will leave a balance of £65. 16s. 5d., which the Directors recommend should be carried forward in equal moieties on account of the Ordinary shareholders and Founders. It is proposed to make the dividends payable on July 1st next.

Mr. George Herring has been elected Chairman of the Company in succession to the late Duke of Marlborough, whose death the Directors deeply regret. The Directors who retire this year are Lord Cloncurry and Mr. Braithwaite, who offer themselves for re-election. The Auditors, Messrs. Rait and Kearton, also retire, and offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

[In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1893, pages 320-348, *&c., &c.]*

CLARKE, CHAPMAN AND CO. (LIMITED).—This well-known business has been registered, under the Joint-Stock Acts, with a capital of £150,000, in £10 shares, as engineers, founders, smiths, and metal workers, of the Victoria Works, Gateshead-on-Tyne.

ELEKTRICITATS-AKTIEN-GESELLSCHAFT VORMALS SCHUCKERT & CO. (NURNBERG).—Under this title a Company has been formed to carry on the well-known works at Nuremberg, founded by Herr S. Schuckert, and conducted for the last year or two under the name of S. Schuckert and Co., Kommanditgesellschaft. The capital is 12 million marks.

ERST UNGARISCHE ELEKTRICITATS AKTIEN-GESELLSCHAFT.—This Company has been formed, with a capital of 6 million marks, to take over the central electric light station at Fiume and that of Messrs. Ganz and Co., at Budapest.

WILLIAM PARNALL AND CO. (LIMITED).—This Company has been registered, with a capital of £30,000 in £10 shares, as iron and brass founders, engineers, makers of engines driven by steam, gas, electricity, or other motive power, electricians, suppliers of electricity, &c., of Victoria-street and Temple-street, Bristol, Manchester, London, and elsewhere.

ORME'S ELECTRIC SIGNAL SYNDICATE (LIMITED).—This Company was registered, on June 15, 1893, with a capital of £7,500, in £1 shares, to carry into effect an agreement between John Orme and Mr. Andrews, for the acquisition of British Patent No. 20,742, 1891, and also a Provisional Specification, entered February 17th, both granted to John Orme for an invention of "Improvements in electrical and automatic signalling," and generally to develop the said inventions. The subscribers, with one share each, are : John Orme, electrical engineer, W. Godbold, C. H. Avey, electrician, W. Powell, N. Mitchell, S. Jennings, and W. M. Grimshaw. The first Directors are to be appointed by the subscribers.

SALT LAKE AND OGDEN GAS AND ELECTRIC LIGHT COMPANY (LTD.).—This Company has been registered with a capital of £300,000, in £1 shares, to carry on in the United States, England, and elsewhere, the business of

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a gas and electric lighting company, including the manufacture, sale, and supply of gas and electricity for lighting, heating and manufacturing purposes, and to construct, manufacture, and maintain works for receiving, holding, storing, distributing, and purifying gas, electricity, steam, and hot water, and electrical plant and apparatus.

UNITED GUTTA-PERCHA AND RUBBER COMPANY (LIMITED) –This Company has been registered in Edinburgh with a capital of £50,000, divided into 25,000 "A" shares of £1 and 25,000 "B" shares of £1 each, to carry on the business of manufacturers of gutta-percha, indiarubber, &c.

GLOBE ELECTRIC COMPANY (LIMITED).—The statutory return of this Company, made up to March 15, 1892, was filed on May 16th. 5,607 shares have been taken up out of a nominal capital of £10,000, in £1 shares, of which 5,500 were issued to Sir William Vavasour, electrical engineer, of Tadcaster, Yorks. Upon the remaining shares the full amounts have been called and paid. The return for 1893, made up to March 15th and filed May 16th, disclosed a similar state of things, no changes having occurred during the year.

LONDON ELECTRIC SUPPLY CORPORATION (LIMITED).—The annual return of this undertaking, made up to May 31st, has been filed, and shows that 111,000 Ordinary and 48,050 Preference shares have been taken up out of a nominal capital of £1,250,000 divided into 200,000 Ordinary and 50,000 Preference shares of £5 each. The full amounts have been called on these shares, resulting in the payment of £798,890. The sum of £3,740 has been paid on 1,950 Preference shares, which have recently been forfeited.

REUTER'S TELEGRAM COMPANY (LIMITED).—The annual return of this concern, made up to June 14th, has been filed, and 11,839 shares have been taken up, out of a capital of £100,000, divided into 12,500 shares of £8 each. Upon each share taken up the full sum has been called, resulting in the payment of £94,712.

SOUTH AFRICAN LIGHTING ASSOCIATION (LIMITED).—3,000 shares of £10 each in this Company were taken up when the annual return was filed on May 30th last. The full amounts were called and paid on 2,895 shares, while the remaining 105 were issued as fully paid.

SOUTHAMPTON ELECTRIC LIGHT AND POWER COMPANY (LIMITED). The annual return of this Company, made up to May 8th, has been filed. The nominal capital is £30,000, divided into 4,000 Preference and 2,000 Ordinary shares of £5 each. 50 Preference and 708 Ordinary shares have been taken up and the full amounts called. The calls paid amount to £3,685.

SOUTH OF ENGLAND HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED).—WESTERN HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED).—The annual returns of these Companies made up to January 13th, have been filed. Each concern has a nominal capital of £100,000, divided into 19,900 Ordinary and 100 Founders' shares of £5 each. The House-to-House Electricity Supply Company (Limited) claims all the Founders' shares as fully paid, in payment for promotion and registration expenses, and the seven original signatories are the only shareholders figuring upon the recently-filed lists.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The annual return of this Company made up to May 30th has been filed. Out of a nominal capital of £2,445,630, divided into 200,000 Ordinary, 34,563 First Preference, and 10,000 Second Preference shares of £10 each, 88,321 Ordinary, 34,563 First Preference, and 4,669 Second Preference shares, have been taken up. Upon each share the full amount has been called, and the calls paid reach £1,275,530.

CITY NOTES, &c

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).—Notice is given that the coupons on this Company's Four per Cent. Mortgage Debentures to bearer, due on July 1st, will be paid on and after that date at Parr's Banking Company and the Alliance Bank, Bartholomew-lane, E.C., and that coupons must be left at the bank for three clear days for examination. Warrants in payment of the interest on the Registered Debentures will be sent out on the 30th inst. The Register will be closed from the 26th to the 30th inst.

AUSTRALASIAN ELECTRIC LIGHT, POWER, AND STORAGE COMPANY (LIMITED).—A meeting is to be held at Messrs. J. H. Duncan and Co.'s, 39, Coleman-street, on July 17th, at 2 p.m., to receive an account of the winding-up of this Company.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The coupons of this Company's second issue of Five per Cent. Debentures, due 30th inst., will be paid on and after that date at Parr's Banking Company and the Alliance Bank, Bartholomew-lane, E.C. Coupons must be left three clear days for examination.

CENTRAL LONDON RAILWAY COMPANY.—It is announced that a prospectus, inviting subscriptions for a large portion of the capital of this Company, will be issued in a few days. The Company is formed to construct an electrical underground railway from Liverpool-street to Shepherd's Bush, and the necessary Parliamentary powers have been obtained.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended June 18th were £782, as against £771 for the corresponding period of last year, being an increase of £11. The total receipts for the half-year amount to £21,034, against £19,385 in the corresponding period of 1892, being an increase of £1,649.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—This Company invite subscriptions for 20,000 Preference shares of £10 each, at a premium of £2 per share. The shares form the remaining portion of 40,000 Cumulative Six per Cent. Preference shares, making up the total capital of the Company to £800,000. Interest is to be calculated from the dates of the respective instalments, which are set out in the prospectus to be found in our advertisement columns. Applications for these Preference shares from registered holders of the existing shares in the Company are to be preferentially considered. The prospectus of this issue states that the Company was formed in 1891, and that the first section of the main buildings of the Company's generating station at Bankside is practically completed, and the second section is making satisfactory progress. It is anticipated that at the end of the current year, or early in 1894, provision will be made for the accommodation of boilers and machinery capable for supplying 200,000 8 c.p. lamps. Further freehold property has been acquired adjoining capable of meeting any extensions the Company is likely to require. Machinery is already in course of construction for supplying 140,000 lamps, and the laying of cables with a capacity for 400,000 8 c.p. lamps, in addition to which 2½ transformer sub-stations are either in course of completion or are completed, and will accommodate equipment for the supply of the 400,000 8 c.p. lamps referred to. It is anticipated that by the end of the current year the Company will be supplying current for 100,000 8 c.p. lamps. The present issue is required for extensions. The list of applications will close this day (Friday), at 4 p.m.——Notice is given that all the transfer books and registers of members of this Company will be closed from June 28th to July 12th, both days inclusive.

FROUDE-HURRELL TORPEDO COMPANY (LIMITED).—A first and final dividend of 2s. 4d. is payable at the liquidator's, 33, Carey-street, W.C., any day except Saturday.

HARROGATE.—The proposal to form a private company for the supply of electric current to Harrogate has been abandoned.

HOBART ELECTRIC TRAMWAY COMPANY (LIMITED).—The interest on Coupon No. 3 of the First and Second Mortgage Debentures will be payable on and after July 1st next at the Commercial Bank of Scotland, Lombard-street, E.C.

HUMPHREYS (LIMITED).—The Directors of this Company declare an interim dividend of 7 per cent. per annum on the Preference and 10 per cent. on the Ordinary stock of the Company for the half-year ending May 31st last. £4,000 is added to the reserve fund, which now amounts to £9,000.

PACIFIC AND EUROPEAN TELEGRAPH COMPANY (LIMITED).—The coupons of this Company's Four per Cent. Guaranteed Debentures, due on the 30th inst., will be paid on and after that date at Parr's Banking Company and the Alliance Bank, Bartholomew-lane, E.C. Coupons must be left three clear days for examination.

PANULCILLO COPPER COMPANY (LIMITED).—At an extraordinary general meeting of the Company, on Tuesday, the Chairman (Sir John Pender, G.C.M.G., M.P.) moved the confirmation of the resolution passed on the 2nd inst., directing the voluntary winding-up of the Company. He said the result of the Directors' application to the shareholders to subscribe for Six per Cent. Debentures did not, unfortunately, furnish more than one-third of the amount which would be required to continue the operations, although the Directors took their full complement. He thought there was no doubt that the Company would be reconstructed, and arrangements would be made to enable those who wished to stick to the old concern to do so. The motion was agreed to.

SIR JAMES SIVEWRIGHT, K.C.M.G.—It is rumoured that Sir James Sivewright has been appointed manager of the Netherlands Railway Company.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee have been applied to to appoint a special settling-day in, and to grant a quotation to, the recently-issued £200,000 Four per Cent. (Mauritius Subsidy) Debentures of the Eastern and South African Telegraph Company (Limited).

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The coupons, due June 30, 1893, on the debentures of this Company, will be paid by Messrs. Barclay and Co., Lombard-street. Coupons should be left two clear days for examination.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED.)—The receipts for the two weeks ended June 15th were £2,724, as compared with £2,609 for the corresponding period of last year. The February receipts, estimated at £5,454, realised £5,508.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended June 16, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,867.

WESTMINSTER ELECTRIC SUPPLY CORPORATION.—This Company have issued, under date of June, 1893, their revised rules to be observed by contractors wiring for the electric light in the district served by the Corporation's system.

PORTHCURNO.—A concert was given by the members of the Porthcurno telegraph staff on Saturday last, after which Mr. G. O. Spratt, Assistant Superintendent, was presented with a set of fruit-servers, the occasion being his departure for Gibraltar, where he has been appointed Superintendent in succession to the late Mr. De Sauty. Mr. W. H. Ash made the presentation, and referred to Mr. Spratt's long service in the Eastern Telegraph Company, and to the prominent part taken by him in organis-

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ing amusements for the Porthcurno staff. Mr. F. C. Judd also referred to Mr. Spratt's past career at Porthcurno. In reply, Mr. Spratt feelingly thanked Mr. Ash and Mr. Judd for their kind appreciation of his services, and extended his thanks to the staff for their universal courtesy and consideration.

REGATTA.—On June 2nd, at Malta, the Eastern Telegraph Company's staff regatta was held, in which the officers of the c.s. "Amber" took part. A very successful and enjoyable day was spent by the competitors and about 250 visitors. After the racing, which consisted of eight events, Mrs. Portelli presented the prizes to the winners.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name	Previous Week's Price, June 14.	Price Wednesday, June 21.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 21. Highest	Lowest.
			TELEGRAPHS			£ s. d.			
£1,134,640	Stock	12/6	Anglo-American	51½ 52½	51½ 52½	5 4 9	Jan., Apr., July, Oct.	51⅝	..
£2,932,680	Stock	25/0	Do. Preferred	94 95	94½ 95½	5 15 2	" "	95½	94½
£2,932,680	Stock	5/0	Do. Deferred	11½ 12	11⅝ 11¾	..	" "	11⅝	..
£195,100	100	4%	African Direct Telegraph 4% Deb. (Reg. & Bearer)	101 104	101 104	3 16 11	January and July ..	103½	..
130,000	£10	3/0	Brazilian Submarine	11⅞ 12½	11⅞ 12½	5 6 1	Mar., June, Oct., Dec.	12⅛	12
£36,400	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107 111	107 111	4 10 1	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock xd	140 150	138 142	4 18 7	April and October	..	..
16,000	10	8/0	Cuba Submarine	11½ 12½	11½ 12½	6 8 0	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	18½ 19½	18½ 19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½ 3½	2½ 3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅞ 12	11⅞ 12½	5 15 8	Jan., Apr., July, Oct.	12⅛	11½
400,000	10	2/6	Eastern	15½ 15⅝	15 15½	4 3 10	" "	15½	15⅛
70,000	10	6%	Do. 6 per Cent. Preference	16⅜ 17½	16⅜ 17½	3 9 7	" "	16⅞	16⅛
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112 115	112 115	3 9 7	May and November	114½	..
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	108 111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	15⅝ 15⅞	15⅝ 15⅞	4 8 2	Jan., Apr., July, Oct.	15⅞	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	112 115	113 116	3 9 0	February & August	115	..
£70,600	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	104 107	104 107	4 13 6	January and July	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor Deb 1900	103 106	103 106	4 14 4	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1900 (regd.)	102 105	102 105	3 16 2	February & August	103½	..
£200,000	£25	..	Do. 4 Mauritius Sub Debs. premium	..	3½ 4	..	May and November	..	..
180,227	10	2/3	Globe Telegraph and Trust	9⅞ 10	9⅞ 10	4 10 0	Jan., Apr., July, Oct.	10	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	15⅞ 15⅞	15⅞ 15⅞	3 15 7	" "	15⅞	15⅝
150,000	10	7/2	Great Northern	19½ 20	19⅞ 20⅛	4 3 9	Jan., April, and July	19⅞	..
£400,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105 108	105 108	4 12 7	March & September	106	..
17,000	25	37/6	Indo-European	40 43	39 42	5 19 1	May and November	40¾	39
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	6 13 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs.	101 104	101 104	3 16 11	" "	..	..
11,802	8	4/0	Reuter's xd	6 7	5 6	..	April and October	..	..
3,381	£100 Cert.	30 0	Submarine Cables Trust 6 per Cent.	120 125	120 125	4 16 0	" "	..	..
15,609	10	5/0	West African Telegraph	5⅛ 6⅛	5⅛ 6⅛	7 13 10	January and July ..	..	..
£260,900	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	100	..
80,000	10	2/0	West Coast of America	3 4	3 4	..	January and July ..	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	103 107	103 107	7 9 7	June and December	..	..
88,321	10	6d.	West India and Panama	1½ 1⅝	1½ 1⅝	..	..	1½	..
84,563	10	6%	Do. 6 per Cent. 1st Preference	10⅞ 11½	10⅞ 11½	5 6 8	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9⅛ 10⅛	9⅛ 10⅛	5 14 3	" "	9⅛	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	108 111	108 111	4 10 1	June and December	..	..
64,242	15	4 6	Western and Brazilian	7½ 7⅝	7½ 7⅝	4 13 11	May and November	..	..
33,129	7½	4 6	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	5 15 8	..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1½ 2	1⅜ 2	..	..	2	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106 109	106 109	5 10 1	February & August	..	..
£222 700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106 109	106 109	5 10 1	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120 125	120 125	5 12 0	May and November	..	..
£169,030	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	1⅛ 2⅛	2 3	..	..	..	..
22,500	14/0	3½d.	Consolidated Telephone Const. & Maintenance xd	1/16 1/8	1/16 1/8	..	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	¼ ⅜	¼ ⅜	..	Yearly	..	..
458 867	5	2/6	National	5⅛ 5⅜	5⅛ 5⅜	7 18 2	June and December	5⅜	5⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref	14½ 15½	14⅜ 15⅜	5 11 7	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14⅜ 14⅝	14⅜ 14⅝	3 18 8	" "	..	..
90,950	5	6⅜d.	Do. 5% Non-Cumulative 3rd Pref. (£3 paid)	5⅜ 5⅝	5⅜ 5⅝	4 1 4	" "	..	..
726 477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	113 117	113 117	..	..	5/16	..
58,000	5	1/0	United River Plate	2½ 3	2½ 3	3 16 11	January and July	..	..
£146.370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	January and July ..	..	..
							" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	11½ 12	11½ 12	..	..	11⅝	..
20,000	10	..	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½ 13	12½ 12⅝	..	..	12⅝	12⅛
19,900	£5	..	Electricity Supply Co. for Spain	..	..	..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	..	5 5½	..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	..
8,322	£5	..	House to House Electric	..	1½ 2½	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..	5⅜ 5⅝	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	6 6½	..	January and July ..	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4 1/16 4 1/16	4 1/16 4 1/16	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6½ 6⅝	6⅝ 6⅞	..	..	..	..
111,000	5	..	London Electric Supply	⅞ 1⅛	⅞ 1⅛	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6 6½	6 6½	3 1 6	..	..	..
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102 105	102 105	4 15 3	June and December	..	..
6,452	£10	..	Notting Hill Electric	5 6	5 6	..	..	..	..
19,980	£5	9½%	St. James' and Pall Mall	7½ 7⅝	7½ 7⅝	..	..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	8 8⅛	8 8¼	4 2 4	..	..	..
59,900	5	2/0	Westminster Electric Supply (fully paid)	5⅛ 5⅜	5⅛ 5⅜	3 0 10	..	5⅜	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/6	Brush Electrical Engineering	3 3½	3 3½	..	..	3½	..
75,000	2	6%	Do. 6 per Cent. Preference	2 2½	2½ 2⅝	5 1 1	..	..	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107 109	107 109	4 2 7	March & September	108¾	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Cumulative Pref	5½ 6½	5½ 5⅝	6 1 9	January and July	5½	..
12,139	5	..	Edison and Swan United	..	..	..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..	1⅞ 2⅛	..	..	..	..
49,900	10	12/0	Electric Construction	2 2½	1⅞ 2⅛	..	..	2⅛	2⅛
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜ ⅝	3/16 ⅜	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	..	..	..
50,000	10	15/0	India Rubber, Gutta Percha & c., Works	22½ 23½	22½ 23½	5 6 4	February & August	23⅞	23½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	2½ 3½	2½ 3½	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	..	..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	5/0 6/0	5/0 6/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid) xd	2½ 3	2 2½	14 11 6	May and November	2½	..
37,350	12	24/0	Telegraph Construction and Maintenance	33 35	33 35	5 3 0	March and July	34	..
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106	103 106	4 14 4	January and July	..	..
39 639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	..	..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	..	..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1%	City and South London Railway	37 39	37 39	2 17 8	May and November	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 789.—Vol. XXXI. FRIDAY, JUNE 30, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

It has been held by the London Electric Supply Corporation that all other metropolitan companies other than themselves would sooner or later suffer from legal proceedings connected with vibration and other nuisance arising from the use of running machinery in densely populated districts. Such difficulties have arisen to a small extent; and one or two cases of damages won by alleged sufferers would stir up all the speculative residents living in the neighbourhood of other stations, sub-transformer stations not excepted. The two cases which are briefly reported elsewhere in our present issue are not calculated to encourage this practice. The estimation of vibration by observing the ripples in a dish of mercury is, if fairly carried out, a sensible method, but fixed conditions should be applied, and the possibility of synchronous vibration with alternating currents or harmonics of mechanical impulses must be avoided. A flash-light photograph of the mercury might be produced in court as evidence. Electric supply companies who have bought up property near their stations have, like rail-way companies who are compelled to take this course, found no difficulty in letting it.

The careful dynamometric and other tests which were at one time carried out by the Royal Agricultural Society, not only added greatly to the interest of their annual shows, but had a most valuable influence on the development of machinery, notably of portable engines. The Cardiff trials are a land-mark in the history of steam-engine construction, and whatever may have been the causes which led to the abandonment of these tests some ten years ago, it is certain that occasional, if not annual, tests of a similar character would be attended with important results. For the first time for several years the machinery section has shown something of its old character, and at the Chester show, which closed last Friday, a very fine collection of gas engines and oil engines was exhibited. Electric lighting has done much to develop and improve both portable steam engines and gas engines for isolated plants, and now that gas engines of 100 H.P. are being built, their use in central stations, either with town gas or with Dowson gas, is sure to follow. Some results of the regular use of a 100 H.P. engine for some three or four months will be found in another column.

The practice of charging for electrical energy supplied during the day-time at a different rate than for that consumed in the evening, is becoming more and more recognised as a mode of equalising the load on a generating station. In America it is supplied at a higher price; in this country the tendency is to supply it at a lower. But the adoption of a cheaper tariff for energy supplied *after* the evening hours of maximum demand, which has just been made at Norwich, comes somewhat as a novelty in methods of charging. In this town consumers taking energy after 8 p.m. on week nights are charged at half the full rate; while on Sundays the lower scale accommodates places of worship by beginning an hour earlier.

After the severe thunderstorms which occasionally break over various parts of the country we receive information of innumerable accidents, and wholesale damage to man, beast and property of all kinds. There is, as a rule, very little originality displayed in these outbursts of electrical activity; but whenever anything of a striking nature occurs we endeavour to find room for it in our Notes, in the hope that some of our readers may make an analytic study of these records with a view to the elucidation of an admittedly recondite subject. Very rarely, as in the instance of a side-flash at Hampstead, the effect of a lightning discharge deserves especial study. We have received from Prof. Lodge an account of a remarkable lightning effect, communicated to him by Mr. Pridgin Teale, the details of which are as follows:—

A short but severe thunderstorm broke over Keighley. At the height of the storm a woman and her eldest daughter were at home. The girl was reading in the living room, her mother having gone into the scullery to fill the kettle, when a vivid flash was succeeded by a tremendous crash. Both mother and daughter were stunned for the time. The mother recovered first and managed to crawl, half-dazed, into the living room, where she found what appeared to be her daughter's dead body lying on the table. The place was filled with dust and wreckage. Several yards of the house gable had been chopped away, and a heavy stone, weighing a hundredweight, had been driven 20 yards with such force as to shatter itself against a wall. Smaller stones and pieces of window glass were picked up 60 yards away. Inside, the house suggested the effects of a dynamite explosion. There was scarcely a whole pane of glass; the walls and ceiling were nearly stripped of plaster and paper, and almost every piece of crockery in the house was more or less damaged. The furniture was splintered or smashed to pieces, one of the window blinds took fire, fire-irons and other pieces of metal were broken, and a kettle, which the mother had in her hand at the moment, was smashed. The lightning appears to have struck the eastern gable, and, after working this mischief, to have left the premises by way of a water-pipe supplying the scullery, which was fused near its junction with the house. In a pigeon-cote near the house a couple of birds were afterwards found dead.

Probably the most remarkable detail in this varied display of energy is the apparent bursting of the kettle in the hands of the woman, who was herself neither killed nor severely

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injured. Considering the fact that the woman and her daughter were temporarily stunned, as well as the immense damage done by pieces of stonework and other things which were hurled about, the present evidence that the kettle was in the woman's hand when broken does not amount to a demonstration.

The interesting communication, which is to be found in our columns this week, on the action of electricity in accelerating the carburation of iron and steel, and which was originally communicated by M. Moissan to the *Académie des Sciences*, suggests that many of our commercial metallurgical processes may be improved and cheapened by the same agency. Metallurgical processes are, as is well known, usually classified under the wet way and the dry way, and in the domain of the former, electrolysis has long had sway; but the direct and general application of electricity to the latter has only quite recently received attention. That ions of incandescent metal and other materials may pass from one electrode to another seems to be established by the curious intermingling of metals which occurs when two different metals, or two different grades of steel, are electrically welded, while it receives additional evidence from the researches of M. Garnier on the production of blister steel by electrolysis in the dry way. It would not appear that any considerable revolution in steel manufacture is likely to arise on account of these researches, for blister steel forms only a small and comparatively unimportant proportion of the steel production at the present day, the Bessemer and Siemens-Martin types of processes being mainly used. But, as an aid to case-hardening, the process appears to be worth consideration. Moreover, if it is possible, electrolytically, to soak carbon into wrought iron and mild steels, it may not be impossible by the same agency to soak it *out*. In other words, we do not see why the useful operation of producing malleable cast-iron by surface decarburation may not be assisted by electrolysis by the dry method. Should this turn out to be the case, the production of malleable castings for dynamos, which is now very common, could be even more generally practised; and it might probably be found that cast-iron thus treated could safely take the place of wrought-iron in many cases where the latter material is now used.

The speculations of Prof. Armstrong as to the nature of the conditions necessary for the occurrence of chemical change, which will be found in another column, are interesting because they constitute an attempt to correlate facts that have been slowly collected by independent observers, but have not yet been viewed as parts of a coherent whole. When it was first demonstrated experimentally that many substances which unite vigorously under ordinary circumstances, fail to do so when a third material, *e.g.*, water, is rigourously excluded, the knowledge came somewhat as a shock to all but those who were not merely abreast of the then latest developments of chemical theory, but were so far ahead of their fellows as to have turned back for instruction to Faraday. As a contrast to the stir thus made, may be quoted the calm—proper to the announcement of a foregone conclusion—that characterised the reception of Mr. H. B. Baker's recent note on the indifference of HCl and NH_3 to each other when mixed in a perfectly dry state. There has been a shifting of our point of view, and, as always, the isolated phenomenon of one day is the commonplace educational text of the next.

The influence of water in bringing about certain reactions is not unqualifiedly accepted by Prof. Armstrong, on the ground that water is not an electrolyte. Its real function may only be to introduce an impurity, possibly an acid, into the sphere of action. The position thus defined is more easily defended than attacked. Its successful invalidation can only be accomplished by demonstrating that water free from any electrolyte will suffice to induce reaction between two substances such as oxygen and hydrogen, which are inert when dry. Seeing that the difficulty of preparing water pure in this sense is considerable, and that no limit can be at present assigned below which the quantity of electrolyte may be neglected, the contention that water itself is not the real determining factor cannot be gainsaid, and to the hypothesis that an electrolyte is requisite must be conceded, whatever support it may derive from this contention. The suggestion that pure gases should be dielectrics, and that the presence of an electrolyte is necessary to permit of the passage of an electric discharge, serves once again to illustrate the need for more collaboration by chemists and physicists when working at the problems that interest both, in order that each may be a check upon the lapses of the other. For critical experiments, gas from a cylinder labelled "so-and-so" will not do.

In a second communication to the Chemical Society, reproduced in our present issue, Prof. Armstrong has given us the result of his cogitations on the nature of depolarisers. The function of depolarisers to suppress a product of electrolysis at the surface of the electrode is tolerably straightforward and comprehensible. If in so doing it furnish energy supplementary to that owing its origin to other portions of the system, it is to that extent more serviceable. The fact that an endothermic reaction can be induced to take place by the simultaneous and interdependent occurrence of one that is sufficiently exothermic to put the balance of heat units on the right side, is a chemical commonplace, and, in fact, is only a particular instance of the general tendency of energy to become degraded, even though it may have to take a temporary step up for that purpose. Prof. Armstrong's phrase that a trace of nitric oxide might exercise "a fermentative action and condition" upon nitric acid is particularly happy, but the nomenclature-purist will fall foul of it we fear.

Testing Electric Supply Mains.—A letter from Dr. Frölich on Dr. Kallman's article on this subject has been held over owing to pressure on our space this week.

Cable Interruptions and Repairs.—

	Dates Interrupted.	Date Repaired.
Fao—Bushire	June 25th	June 28th.
Paramaribo—Cayenne	April 15th	—
St. Thome—Loanda	May 30th	—

Conversazione.—A highly successful conversazione of the Institution of Electrical Engineers was held at the rooms of the Royal Institute of Painters in Water Colours on Friday last.

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"Electricity and Biology."—In the July number of the *Humanitarian*, Mr. W. H. Winny writes an interesting article on this subject. Readers will find a general survey of the evolution of scientific opinion as to the relationship of electricity to life from the crudities of the time of Dr. Gilbert to the speculations of the present day upon the influence of electricity on vegetable growth and animal functions of health and disease.

A New Welding Process.—M. Julien, of Paris, has invented a process of electric welding in which the metal to be welded forms one pole of an electrolytic cell containing dilute sulphuric acid. The evolution of hydrogen around this pole by the passage of a strong current is sufficient to isolate the metal from the liquid; when the high resistance causes sufficient heat to raise the metal to white heat. Temperatures up to 4,000°F. can, it is said, be obtained.

Electricity in New Zealand Mining.—In a recent issue our New York contemporary, the *Engineering and Mining Journal*, gives a fine view of the Phœnix Mill, Otago, New Zealand, which is the most important mill in the oldest and best-known gold mining district in New Zealand. This mill was one of the pioneers in the use of electricity for the transmission of power, the plant having been erected in 1884. It consists of two Pelton wheels, receiving water under a head of 180ft., and driving two Brush dynamos. These are connected by a wire line, nearly three miles long, with the motor at the mill.

Who is Tessler?—The following extract from the *Cape Times* may interest our readers:—"Tessler lectured over here a few years ago, and since then he has pursued his investigations much further. His new lecture, delivered in the States, has just been issued, and is being perused with absorbing interest by electricians. Tessler is described to me by a former colleague as an exceptionally fearless man. The first experiments which he made exposed him to the most fearful risks. He literally played with forces of electricity—up to a hundred thousand volts—which might, for aught he knew, have reduced him to a cinder any moment."

The Munsie-Coles Slot System of Electric Traction.—The *Electrical Engineer* of New York describes in a recent issue the Munsie-Coles slot system of electric traction, which is in use on an experimental line at Hartford (Conn.). An insulated cable is tapped at 16ft. intervals into contact boxes. Contact is made by means of a long strip of metal, carried by the car. This strip fills the slot of the conduit, and presses on a grooved roller in each box; the pressure forces a wedged-shaped piece of metal between two spring clips connected with the feeder. The chief apparent advantage of this particular system is the likelihood of high insulation.

Physiological Effects of High Frequency Currents.—The *British Medical Journal* of June 24th contains a short article by Dr. Lewis Jones, exposing the supposed harmlessness of high-frequency currents. He points out, as has been done repeatedly in *The Electrician*, that this wide-spread fallacy arises from erroneous ideas about the magnitude of the currents. He discusses M. d'Arsonval's experiment with a glow-lamp, and shows the errors of his reasoning. An effusion by a Mr. Lynch, in an evening paper of yesterday, contains the following:—"The mere description of Tesla's actual experiments reads like an impossible fairy tale. Those who have felt the 'shock' from a small battery of a single cell will be astonished to learn that Tesla passes through his body a current two hundred thousand times as 'strong,' and yet lives to repeat the experiment."

Marking Meat by Electricity.—The Select Committee of the House of Lords, presided over by Lord Onslow, appointed to inquire into the matter of marking imported foreign meat, had before them on Friday, among other witnesses, Mr. E. Manville, electrical engineer, London, who suggested the accomplishment of the process by means of electricity. He submitted an appliance consisting of a wheel, needled in the circumference, which when connected with an electric-current would, passed over a carcase, make a continuous mark skin-deep; and for a straight line various figures could be substituted, even letters, such as "N. Z.," for New Zealand. Where, as in slaughter-houses provided with the electric light, an electric current could be readily obtained, the cost of the apparatus would be very small; and where there was no such means of obtaining the current the cost would be about £100. Further, the marking could be made an easy, speedy, and, for all parts of the carcase, effective process. The Committee seemed considerably interested in the device.

Effect of a Gaseous Envelope on the Resistance of a Metal.—A short time ago a discussion arose as to the cause of certain small increments in resistance which an ordinary bare copper wire receives on immersion in various gases, experiments upon which had been made by Mr. Fernando Sanford. We have received from Prof. Fessenden a suggestion which would appear to throw some light upon the nature of the phenomenon, at any rate in so far as it relates to gases which have any chemical effect upon the conductor at ordinary temperatures. "If we suppose," writes out correspondent, "that when a wire is placed in a gas-like sulphur dioxide a thin film of a compound of the copper and the gas is formed, only the $\frac{1}{25}$th thousandth of an inch in thickness, it will account for all the phenomena observed by Mr. Sanford. For, as the wire experimented with was 1mm. in diameter, the formation of a layer of this thickness would reduce the cross-section of the copper by 0·2 per cent.," which would correspond with the maximum change in resistance observed by Mr. Sanford. The crucial test of the validity of this explanation is, of course, an examination of the electrical effect, if any, of gases which are known to have no chemical action upon the metal used, and a careful comparison of the observed results with the results obtained when chemically active gases are employed.

Railway Enterprise Development.—We have received introductory pages and two beautifully executed "Woodbury-gravure" plates, being advance proofs of a forthcoming work by Mr. Athol Mayhew, to be published by Messrs. Eyre and Spottiswoode. Some of the objections raised to the introduction of railways, recorded by Mr. Mayhew, may be read with interest in connection with the not unlike feeling in some quarters about electric traction:—

> The country gentry were told that the smoke would kill the birds as they passed over the locomotive. The public were informed that the weight of the engine would prevent its moving. Foxes and pheasants were to cease in the neighbourhood of a railway; the race of horses would become extinct. Farmers were possessed with the idea that oats and hay would no more be marketable produce; horses would start and throw their riders. Even cows, it was said, would cease to yield their milk in the neighbourhood of one of those infernal machines. "What," asked Sir Isaac Coffin in the House of Commons, "was to be done with all those who had advanced money for making and repairing the turnpike roads? What was to become of coachmakers and harness-makers, coach-masters and coachmen, innkeepers, horse-breeders and horse-dealers? Was the House aware of the smoke and the noise, of the hiss and the whirl, which locomotive engines passing at the rate of 10 or 12 miles an hour would occasion? Neither the cattle ploughing in the fields nor grazing in the meadows could behold them without dismay. Iron would be raised in price a hundred per cent., or, more probably, altogether exhausted. It would be the greatest nuisance, the most complete disturbance of quiet and comfort in all parts of the kingdom, that the ingenuity of man could invent."

The Alleged Theft of Blue Prints.—With reference to the statement made by our American correspondent concerning the alleged stealing of blue prints from the offices of the Westinghouse Company, Dr. Bell writes as follows:—"I notice in your issue of June 2nd, in the American Notes, a statement regarding the recent charges made by the Westinghouse Company against the General Electric Company, that seems to call for a few words of explicit denial. The facts are these:—The chief engineer of the Westinghouse Company, under cover of officers, entered the works of the General Electric Company, on the pretence of being a prospective customer, and then exposing himself he had a search made for the alleged stolen blue prints. He found nothing that had the remotest connection with the Westinghouse Company, and he then departed. The plans alleged to have been stolen were those for the utilisation of the water-power at Niagara Falls. As I was responsible for the plans of the General Electric Company for this work, I can state that the allegation was absolutely false. Furthermore, the Cataract Construction Company promptly published a letter denying any similarity between the plans of the Westinghouse Company and the General Electric Company for their work, greater than was found between the

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numerous plans proposed by other engineers. I feel that in justice to the General Electric Company and to myself as well, the facts in the case should be known."

Science and Manufacturing in Germany.—In an article in *Nature* for May 11th Prof. Armstrong gives an interesting account of the chemical research laboratory attached to a dye works at Elberfeld, and is moved to speak of the absolute necessity for a proper recognition of science by our own manufacturers in the following terms:—"A true conception of what a chemist is, what he is called on to do and to know in this age of progress, must arise in high quarters and especially among our manufacturers. Our children must be properly taught at school and trained to work as well as to play, and we must cease to worry their lives at college by insisting on the study of a multiplicity of subjects, and no longer attempt to develop a Chinese system of examinations. Surely it is time that we realised that our examination system is a fraudulent failure. In Germany the victory has been gained wholly and solely through the agency of the universities; here we are still dominated by influences which had their origin in the monkish cell, and our ancient universities do nothing to help us. The intolerant individuality which has enabled us to conquer and to govern where other nations have failed is of little use in an industrial war against the most systematically instructed people in the world, whose weapons are scientific research and scientific method, and who have been careful to 'organise victory' to use Huxley's expression in his remarkable letter in *The Times*, at the time that a proposal to establish an Imperial Institute was under discusion. Huxley warned us six years ago of the fate that awaited our industries if we did not organise victory. I fear that so far as chemistry is concerned, our insular conservatism still leads us to turn a deaf ear to all such warnings, and that the only change is that we are six years nearer to our fate."

Earthing Device for Transformers.—Our readers will remember that under certain regulations made by the Board of Trade, it is necessary to provide some form of safety device which will prevent a dangerous voltage from arising on low-pressure circuits fed from high-pressure mains. The Sharp and Kent system of interposing a layer of wire between the windings of a transformer was the first to receive official sanction. The subjoined notification shows that for this purpose the well known earthing device invented by Major Cardew has also been approved:—

Whereas, in certain regulations made by the Board of Trade under the Electric Lighting Acts, 1882 to 1890, and certain Provisional Orders and Licenses granted under those Acts, it is provided that where the supply of energy is transformed at a converting station, some means or apparatus approved by the Board of Trade shall be provided which shall render it impossible that the low-pressure distributing mains shall be at any time charged to a dangerous difference of potential from the earth, owing to any accidental contact with, or leakage from, the high pressure system, either within or without the converting station.

And whereas in such regulations it is also provided that where any transforming apparatus is installed on a consumer's premises, some means or apparatus approved by the Board of Trade shall be provided, which shall render it impossible that the low-pressure service lines and consumer's wires shall be at any time charged to a dangerous difference of potential from the earth owing to any accidental contact with, or leakage from, the high-pressure system either within or without the transformer.

Now, therefore, the Board of Trade approve of the apparatus known as the Cardew earthing device of the pattern deposited at the Board of Trade Laboratory, sealed, and numbered 3, 3A, and 3B, for use under such regulations.

Provided that in all cases in which such devices are used suitable quick-action fuses or cut-outs are inserted in the high-pressure circuits, and that in any case where the high-pressure current to the transforming apparatus may exceed 30 amperes, two such devices at the least shall be used.

Signed, by order of the Board of Trade, this twentieth day of June, 1893.

(Signed) FRANCIS J. S. HOPWOOD,
Assistant Secretary Board of Trade.

Magnetic Qualities of Iron.—A Paper by Prof. J. A. Ewing, and Miss Helen G. Klaassen, Lecturer in Physics, Newnham College, has been communicated to the Royal Society. The Paper describes a series of observations of magnetic quality in various specimens of sheet iron and iron wire. A principal object was to determine the amount of energy lost in consequence of magnetic hysteresis when the iron under examination was carried through cyclic magnetising processes between assigned limits of the magnetic induction **B**. Many cycles were gone through in the case of each of the specimens, the limits between which **B** was reversed being varied step by step in successive cycles, to allow the relation of the energy expended or of $\int \mathbf{H}\, d\mathbf{I}$ to **B** to be determined. The iron examined was, for the most part, thin sheet metal or wire such as is used in the construction of transformer cores. The experiments show that there are marked differences in the values of $\int \mathbf{H}\, d\mathbf{I}$ in different specimens, some nominally soft iron requiring two and even three times as much work to be spent in reversing its magnetism as is required in the best iron. They show, further, that great permeability does not necessarily imply small hysteresis losses. It is shown that although the formula proposed by Mr. C. P. Steinmetz ($\int \mathbf{H}\, d\mathbf{I} = c\,\mathbf{B}^{1.6}$) may serve fairly well as an approximate statement of the relation within those limits of **B** which are important in practice, it fails when applied to the more extreme portions of the curve. The Authors go on to describe a second group of experiments, in which direct measurements were made of the heat developed in magnetic reversals. The method consisting in using two rings, alike in all respects, with divided magnetising coils, was described in *The Electrician*, Vol. XXVII., p. 631. The Authors could not detect any difference in the amount of energy consumed in the core when the "load" was taken off or put on the secondary. In a third group of experiments the magnetic curve tracer was used. The time-lag in magnetisation is well shown by the curve-tracer, and the effects are compared of the same cycle of magnetic force gone through at various speeds. It is shown that in solid bars 1·9 cm. in diameter, especially in soft iron, remarkable evidences of time-lag are seen, even when the period of magnetic reversal is as long as 3 seconds. The work spent per cycle is maximum at a particular frequency, which in such bars is very low.

Cheap Gas Engine Working in Belfast.—In connection with the meeting of the Gas Institute, says the *Journal of Gas Lighting*, it should be recorded that an interesting and important illustration of the efficiency of gas-engines to compete with steam-engines for ordinary mill work was afforded at the linen factory of Messrs. Thompson, Rogers, and Co., in Belfast. There is one Tangye gas-engine of 100 H.P. at work, supplied with gas from a Dowson producer; but it is stated that as the demands upon the establishment increase two more engines of the same size will be put down. Gas-engines of 100 H.P. and even more have frequently been heard of, but seldom seen. Here we have an example of a gas engine capable of indicating 100 H.P., that has been working every day for the past three or four months to the complete satisfaction of the owners, and supplied with Dowson gas from a generator consuming anthracite coal after the rate of 2½ tons per week, costing on the spot 20s. per ton. The necessary attendance is given by one handy man, whose wages are £1 per week; so that the special expenses of working under this system are £3. 10s. per week. This, of course, is exclusive of wear and tear and interest on the Dowson part of the apparatus. The question may be asked: How does this plant compare with a coal gas supply? In the circumstances, the millowners are doubtless pursuing the cheapest plan; for, taking the consumption of coal gas by a Tangye engine of large size at 25 cubic feet per indicated horse-power per hour, the consumption for 100 H.P. for a working week of 56 hours would amount to 130,000 cubic feet, which would cost £14. 12s. 6d. There is plenty of margin between this figure and that of £3. 10s. already given to pay for interest, wear and tear, depreciation, rent of space, and extra labour, and still leave a difference in favour of the Dowson gas. With regard to steam-power, at the rate of 3lb. of coal per indicated horse-power per hour, the consumption of a 100 H.P. boiler would be 7½ tons per week, costing between £6 and £7 on the spot. Upon the power actually used in the mill the fuel comsumption is about 1¼lb. per indicated horse-power per hour, a sufficiently low average on which to congratulate the designers. It is an additional recommendation for gas-engines in mills that the convenience of having the power in 100 H.P. units enables it to be put down wherever required. This is a great consideration, since it means a saving of the cost and friction of the countershafting that in a steam-driven mill runs away with a heavy proportion of the total power developed by the main engine.

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ELECTRIC MOTIVE POWER.*

BY ALBION T. SNELL.

(*Continued from page 119.*)

§ 14. Series, Shunt, Compound, and Separate Excitation.

It is of the utmost importance to fully appreciate the differences between the various methods of exciting the field-magnets, as all are not equally well adapted for all kinds of work, some being specially suitable for one class, and worse than useless for others. It is probable that the connections of the several windings are well known to most readers; yet it will serve to fix ideas and to give a firm grip of the various purposes to which each type of machine may be most profitably applied if the following sets of diagrams are carefully examined.

In each set the first figure shows simply the diagram of connections, irrespective of the arrangement and number of the field coils and poles.

The second figure refers to a dynamo wound as indicated in the first figure, and shows the order of the curve connecting the terminal, or omnibus bar pressure with the main current.

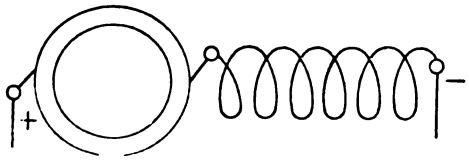

Fig. 15A.—Series Winding.

The third figure refers to a motor wound in the same style, and indicates roughly the shape of the curve connecting the number of revolutions per minute with the main or armature current.

The dynamo speed is in each case assumed to be constant, and so also is the pressure at which current is supplied to the

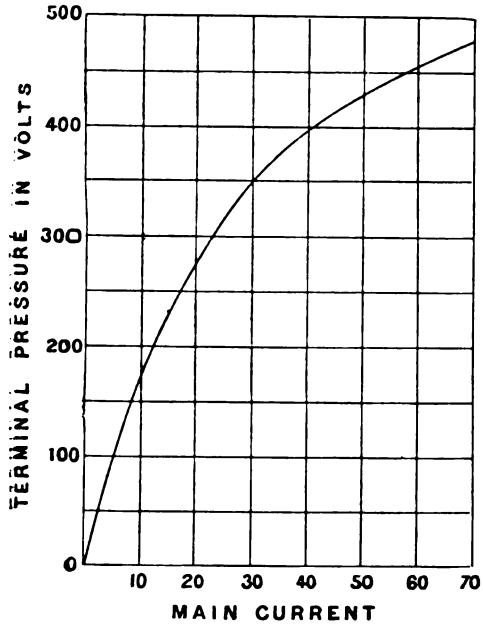

Fig. 15B.—External Characteristic Curve of Series Dynamo.

motor. These conditions are usually essential, and are conformed to, as nearly as possible, in all central stations.

The diagrams are so explicit as to need little comment, but a few suggestions may be useful.

The pressure in series-wound dynamos varies with the current, and hence these machines are only suitable for working on a constant resistance, such as a definite number of arc lamps or a fixed number of incandescent lamps; they are more especially adapted for the former work. They present one very apparent advantage in the fact that, since the main current passes through the field winding, the number of turns of wire on the magnets is comparatively few, and the wire is large, and therefore strong. High insulation resistance is thus easily obtained without mechanical difficulty or the use of costly material. For power purposes this winding possesses special value. Consider Fig. 15C, which refers to a series motor running at constant pressure. It will be seen that as the

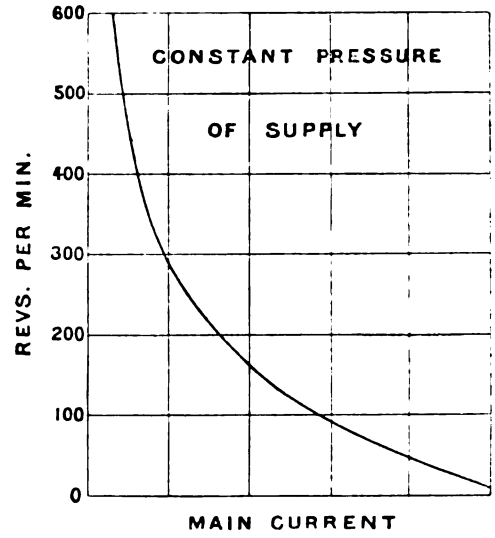

Fig. 15C.—Mechanical Characteristic Curve of Series Motor. Abscissæ Proportional to Torque.

current in the motor is increased the speed decreases, which is equivalent to saying that the torque varies inversely with the speed. Now, look at the series dynamo curve, Fig. 15B. As already pointed out, the pressure increases with the current, which is exactly the condition of supply to make the series motor run at a uniform rate of speed. Therefore, if a series-wound dynamo be coupled to a series-wound motor, and be driven at a constant speed, it will supply current at a pressure varying directly as the current and the motor will tend to run at a constant speed. This is such an important problem in the electric transmission of power that it will be referred to again, and the conditions for success examined more closely.

Series motors are suitable for a variety of purposes, and are generally used where a large torque is required at starting, and a fairly constant load obtains afterwards. When run off constant-pressure circuits, they are regulated by a variable resistance placed in series with them, and altered by hand as occasion requires.

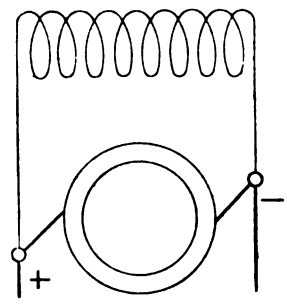

Fig. 16A.—Shunt Winding.

The *feature* of a series motor to be specially remembered is that the torque is greatest at starting, when the current is a maximum. This is so because the main current passes through both field and armature coils, and magnetises them to the greatest possible degree.

Shunt-wound dynamos give variable current at fairly constant pressure. They are therefore suitable for running loads, such as banks of lamps, which require varying power; and also *series-wound motors with constant loads*, or *shunt-wound motors with varying loads*. This is seen to be the case by comparing the shunt motor mechanical curve (Fig. 16C) with the shunt dynamo curve (Fig. 16B). The shunt motor when supplied at constant pressure maintains a fairly uniform rate

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of rotation with varying load; the shunt dynamo *approximately* conforms to the supply conditions.

The shunt motor is not so well adapted for starting against a heavy torque as the series motor. For the shunt field excitation cannot exceed that determined by the supply pressure; and a sudden rush of current through the armature at starting tends to weaken the field magnetism unless the brushes have a forward lead, when there will be considerable sparking. When starting a shunt motor, the field circuit should be first closed, and time allowed for the magnets to become fully excited before the armature circuit is closed through the starting resistance, always used with these motors. After the armature has commenced to revolve, the resistance may be gradually cut out and the speed raised to its normal value.

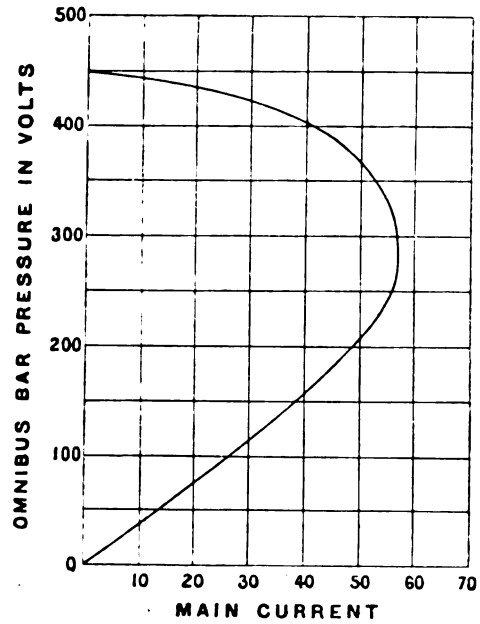

FIG. 16B.—External Characteristic Curve of Shunt Dynamo.

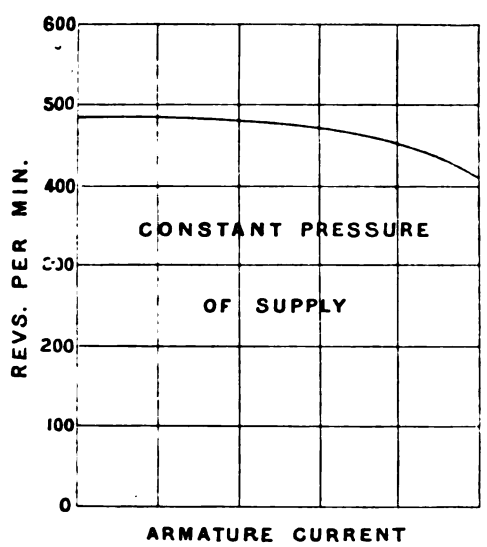

FIG. 16C.—Mechanical Characteristic Curve of Shunt Motor. Abscissæ proportional to Torque.

The *feature* of a shunt motor to be specially recollected is that it will run at nearly constant speed, with varying load, when supplied with current at constant pressure. This is the supply-condition of nearly all central-power stations, and hence shunt-motors have a special field in this connection.

As will be gathered from Fig. 17A, compound winding is a combination of the shunt and series methods of excitation. The shunt coils may be coupled across the brushes in "short shunt," or across the mains in "long shunt," as shown in Fig. 17A. The theory is as follows:—The shunt coils give an excitation proportional to the terminal pressure, and the series coils an excitation varying with the armature or the main current, according as the long or short shunt be adopted. It is evident that, by suitably proportioning the two windings, the external characteristic, Fig. 17B, can be made to slope at any angle to the current line; or, briefly, the pressure may be made to increase with the current, and, compensating for the fall in the feeders, maintain a constant pressure at the centre of distribution. The chief difficulty with high-tension compound dynamos is the shunt windings, which consist necessarily of many turns of fine wire, and give trouble from a variety of causes, besides being costly.

The mechanical characteristic of the compound-wound motor is shown in Fig. 17C. It will be seen that there are two methods of coupling up the coils, as suggested in curves 1 and 2. In the top curve the shunt and series excitations are differential, *i.e.*, the series coils demagnetise the field-magnets; in the lower curve they are cumulative, and both act in the same direction. The differential coupling is theoretically the better arrangement, and gives a more constant speed than even a shunt motor, as is apparent from equation (6) $E_m = C_a N_a n \frac{10^{-8}}{60}$, where E_m is the motor armature counter-electromotive force, C_a the number of armature conductors, N_a the lines of force, and n the revolutions per minute. Since C_a is constant, and N_a may also be regarded as such when a constant pressure acts on the shunt coils, it is clear that the speed, n, varies directly as the counter electromotive force, E_m. And the armature reactions do not affect the problem if we assume the current to have no effect on the value of N_a. Now,

$$E_m = e - i_a r_a,$$

where r_a is the armature resistance, and i_a the current in the armature, and e the pressure of supply. It is clear that E_m varies inversely with i_a, and, therefore, the shunt motor tends to slow as the current increases (for the speed is pro-

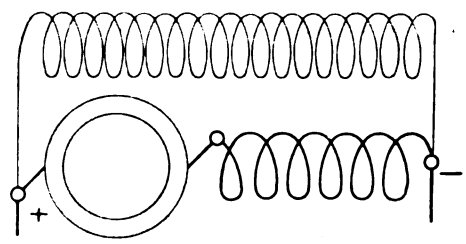

FIG. 17A.—Compound-Winding Long Shunt.

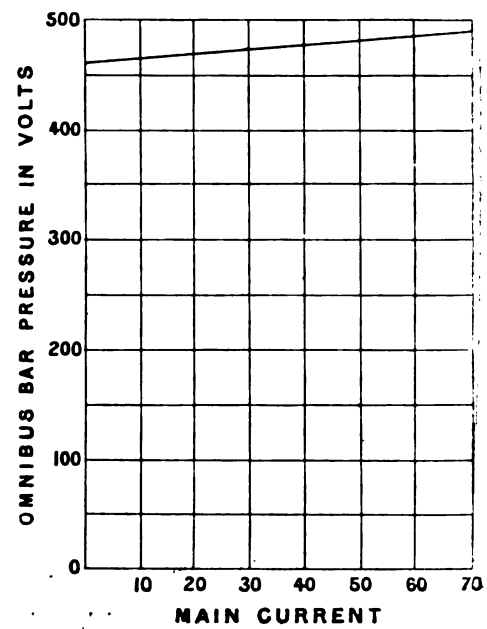

FIG. 17B.—External Characteristic Curve of Over-Compounded Dynamo.

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portional to E_m). Referring again to equation (6) it is seen that to prevent this falling off in speed it is necessary to decrease the lines of force, N_a, in the same proportion as the fall of counter-electromotive force. This is most readily accomplished by decreasing the excitation, either by intercalating resistance in series with the shunt circuit, or by adding compound series coils wound in an inverse sense to the shunt turns. The armature reactions always weaken the main magnetic field, and therefore tend to make a shunt-motor run at a constant speed. It is thus possible to obtain nearly a

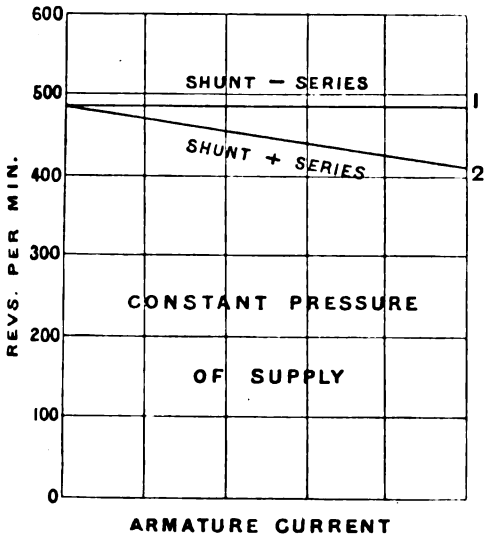

Fig. 17c.—Mechanical Characteristic Curve of Compound Motor. Abscissæ proportional to Torque.

straight line speed regulation with a well designed shunt-motor. A motor armature, then, should have a very low internal resistance, the smaller the better.

The cumulative method is more frequently used, for although it obviously does not regulate so well as a simple-shunt motor, yet it combines, to some extent, the starting power of the series winding with the speed regulation of the shunt. Sometimes a few series-turns are wound on large shunt motors, and are used only at starting, being short-circuited, as soon as the armature is fairly under weigh.

Broadly speaking, differentially-wound compound motors do not seem to be a success, and except for the few cases where absolute regularity of speed is required, they certainly have not found favour. Cumulative compound motors have also a

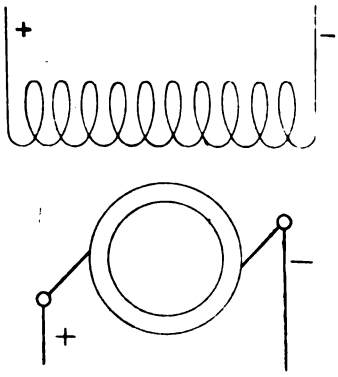

Fig. 18a.—Separate Excitation Winding.

very limited field of usefulness, well-designed shunt machines being more efficient, and giving better speed regulation. Yet there are some few applications where this winding will meet the conditions better than any other.

The *feature* of compound-winding to be specially noted is that, by applying it to the generator, the pressure at a distance point can be maintained automatically constant with varying current.

The idea of separate excitation is so easily grasped that there is no need to do more than refer to Fig. 18a, which is a diagram of the connections, the top scrolls representing the field-magnet coils. It is obvious that the number of turns on the field-magnets and the gauge of wire can be varied to suit the exciting current as long as the necessary excitation is provided. In Fig. 18b the external characteristic of a separately excited dynamo is shown at curve 3. It will be noticed that the

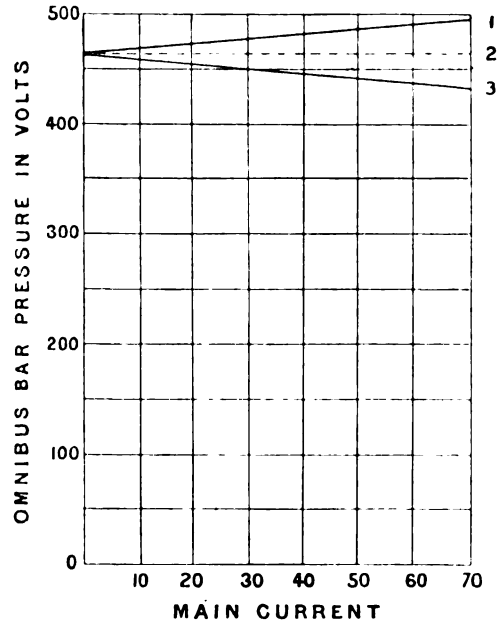

Fig. 18b.—External Characteristic Curve of Separately Excited Dynamo with Constant Excitation.

pressure falls as the output is increased, owing to the volts lost over the internal resistance of the armature. To obviate this the excitation must be proportionately augmented, so as to give curve 2. And if it be desired to compensate for the fall of pressure in feeders, then the exciting current must be still further increased until the slope of curve 1 suits the required conditions. The regulation can be accomplished automatically

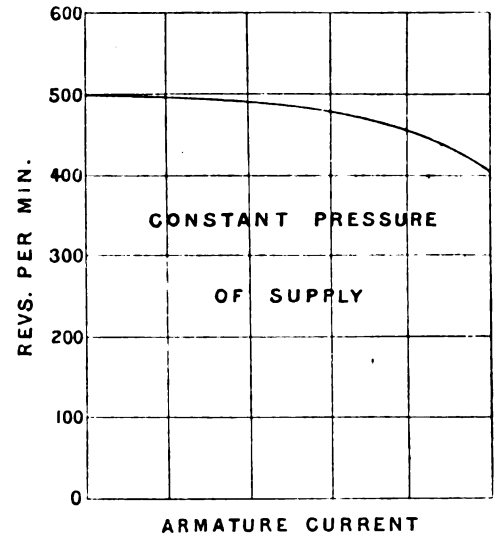

Fig. 18c.—Mechanical Characteristic Curve of Separately Excited Motor. Abscissæ proportional to Torque.

by some mechanical device controlled electrically; but it is usual in central stations, where this type of machine is most frequently used, to alter the excitation by hand.

The separately excited motor is not as yet much in use, but it will steadily grow in favour as transmission of power by electricity becomes more general. The mechanical characteristic of this type of motor, supplied at constant pressure, is shown in Fig. 18c. The fall of speed with increase of load can be compensated by *decreasing* the excitation either by hand regulation or reversed series coils.

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These motors are specially adapted for large powers, because since the main current only passes through the armature, a high pressure can be safely used, and, moreover, the speed regulation is much superior to that obtainable with the series-winding. The objection is the independent source of power for the exciting current, which will probably have to be supplied in most cases from accumulators. Yet it must be recollected that a small shunt-dynamo, driven by the large motor will not only charge the cells, but also excite the motor field-magnets after the proper speed is once attained; and, further, this dynamo is available for lighting during the period the motor is at work.

The advantages of separate excitation are: firstly, the dynamo fields can be excited at a low-pressure, and hence are free from insulation troubles; secondly, lightning discharges are less likely to affect the magnet coils, since they are not connected to the line circuit (unless reversed series coils be used); and, thirdly, the pressure at any distant point can be easily varied at will. And with motors a high-pressure service is permissible, and the speed can be regulated either by the dynamo or motor exciting current.

(*To be continued.*)

ELECTRIC LIGHTING IN BARCELONA.

The electric light was introduced into this town by the Sociedad Española de Electricidad in the year 1882, the first operations consisting in running a few arc lamps from Gramme dynamos, which are still in use. At the present time, besides the glow lighting, there are 315 arc lamps at work, each taking 15 amperes at 50 volts. The earliest attempts at glow lighting were on the direct-current series system, but were not successful, but during April, 1891, the parallel-transformer, high-pressure system was adopted. There are now some 12,000 10 c.p. glow lamps connected to the transformers. The central station is situated close to the docks and town, the site being very convenient for coaling. There are in all nine steam engines, by various makers, viz., two 100 H.P. Corliss condensing engines, driving a line of counter-shafting for arc-light machines; two 150 H.P. condensing engines, driving Ferranti alternators by means of ropes; two 60 H.P. vertical engines, direct-coupled to dynamos for emergencies; one 60 H.P. Corliss condensing engine, which is used for driving a Mordey alternator by day and arc lighters by night; one 40 H.P. engine for a private arc circuit; besides one 300 H.P. compound condensing engine, which has just been added for driving a large Ferranti alternator. There are seven boilers, two of 200 H.P. and two of 100 H.P., of the water-tube type, and one 60 H.P. Lancashire boiler. These all supply steam at 85lb. pressure, but in future extensions it is intended to work up to 110lb. It will be seen that the plant is of a very mixed type, and much of it, being of old patterns, has a low efficiency. The arc lighting, for instance, is carried out on a system designed by M. Gramme, the arcs being maintained in series of 10 to 20 lamps, and regulated by means of iron-wire resistances, which are thrown into or out of the circuit by hand. As most of the arc light machines are small, they have to be worked in series in order to get the required voltage. The efficiency of the countershaft and arc light system is only 50 per cent. Moreover, the tendency of the dynamos on this system to reverse polarity makes it necessary to provide every arc lamp with a reversing commutator, in order that the current shall be conveyed through the carbons in the right direction. This system, as can be seen at a glance, is not a satisfactory one, and a motor-commutator and transformer are being supplied by Messrs. Ferranti and Co., for the purpose of running the arc lamps with a rectified current from the alternators. This would raise the efficiency from 50 to 80 per cent., and would halve the cost of maintenance.

The 300 H.P. Ferranti alternator is mounted on a cast-iron sole plate, and, for convenience in cleaning or repairs, is made in two halves, which can be moved apart by means of a screw arrangement. The field-magnets consist of 28 pairs of bobbins, 14 pairs on either side, and are built up of sheet-iron stampings pressed into the form of a horse-shoe magnet. The stampings are held together by iron rivets, and the magnets thus formed are bolted to the cast-iron frame. The armature is built up of 28 bobbins, which are coupled up into two series arranged in parallel. Attached to the bobbin-holders are a number of metal rings, which act as a fan, and cause a ventilating draught through the armature. This alternator is excited by means of a direct-current Statter dynamo, the armature of which is mounted on the alternator shaft. The exciter supplies a magnetising current of 50 amperes at 110 volts. The bearings of the alternator are of the swivel-ball pattern, and are provided with water glands. The linings, which are of white metal, are lubricated with oil supplied from force pumps. These pumps are worked by eccentrics on the alternator shaft, and supply the oil at a great pressure to the bearings, whence it drains into a cistern at the side of the machine, and is pumped back again to the bearings. In the event of either of these pumps failing, oil is supplied from a cistern about 15ft. above the dynamo, the height giving a head sufficient to force the oil between the bearing surfaces.

This machine is run at a speed of 295 revolutions per minute, and gives 90 amperes at 2,600 volts. Its height over all is 9ft. 6in., and the floor space covered by the bed is 10ft. 8in. by 8ft. 10in. The diameter of the armature is 8ft. 4in., and of the armature boss 5ft. 3in., and the clearance between the armature and the field-magnets is 1¼in. The shaft, which is 12ft. in length, is set in bearings of 2ft. length.

The main distributing switchboard for the glow lighting is made up of four feeder circuits and four distributors for the dynamos, each circuit having two sets of fuses and a double-pole switch, so that any circuit may be changed over instantly from one dynamo to the other. The sub-central point, or feeding point, is situated about a mile from the central station, in the midst of the densest part of the wiring. It consists of a small underground room, divided into three parts. The first part contains a board for the four feeders, and six pairs of fuses; the second part, another board, with ten pairs of fuses; and the third part, a telephone exchange for communicating with various points in the network of mains. Any of the four feeders from the central station can be plugged on to either of the ten distributing cables, and the voltage at the coupling boards is maintained at 2,550 volts, there being a 2½ per cent drop per mile in the cables. There is also, at this point, a large transformer which supplies a local low-pressure network at 105 volts. The various distributing circuits which leave the sub-central point are carried to various parts of the town, and are again sub-divided at numerous junction boxes. These boxes are placed in excavations under the footpath, and are lined with brick and cemented over. Air transformers are placed in these boxes, each transformer supplying the lamps within 100 yards radius of the box. The whole of the main cables are tested daily just before starting, and are tested by means of a vacuum tube several times during the day's run.

ELECTRIC MACHINE TOOLS.

Rather more than a year ago we commented on the numerous types of steam engines which have been designed for special purposes. The factory engine, the marine engine, and the locomotive differ so widely, both in general arrangement and in detail, that the casual observer might be excused if he asked whether so dissimilar machines had anything in common. We called attention to the apparent want of adaptability of the electric motor as generally made, not, indeed, that it cannot be applied to all sorts of duties, but that it is generally merely taken from stock and geared to the work by gear-wheels or belts. A recent article by Mr. Wheeler, one of the joint inventors of the well-known Crocker-Wheeler motor, shows that this apparently un-engineer-like principle of tacking a motor on to a machine is not so bad as it at first sight seems. In this article in the *Electrical Engineer* of New York a number of machine tools were illustrated, and in the majority

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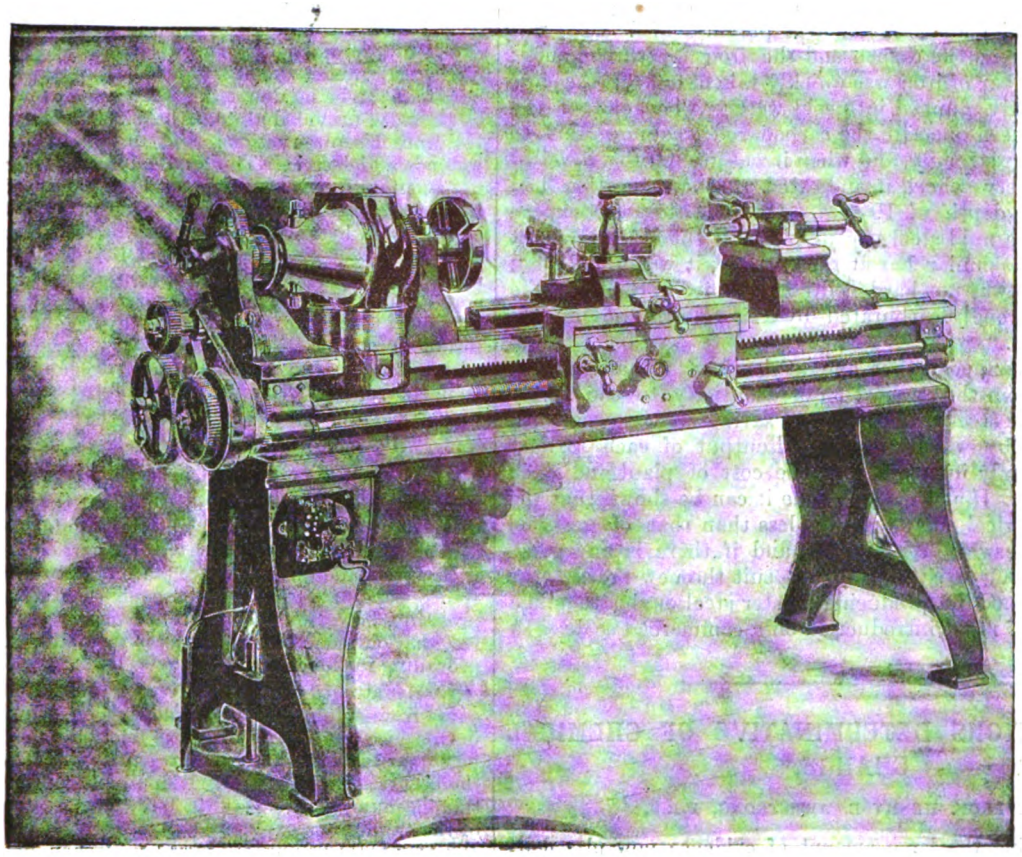
of cases the motor seemed to allow itself to be grafted into the machine and to form a part of it, in an unexpected manner. We applied to the General Electric Company, the agents in this country for the Crocker-Wheeler motor, for further particulars of these adaptations, and are enabled to illustrate a power lathe driven in this fashion. The armature of the motor, well boxed in, takes the place of the ordinary speed cone; while a starting and control switch placed, in this case, perhaps rather low, enables the turner to start and stop and to change his speed within limits, in a very simple manner. For continuous work of one kind, a change of speed is seldom required, and still less is a change of power or for large tools on which a variety of work is done, the direct application of a motor is more difficult, unless some sacrifice is made. Small as is the power, something better than toy motors, such as are used for driving fans and dentists' drills, is required. We were amused to learn from a correspondent that in his opinion one reason for the comparatively small demand for motors in this country is that "electricians in charge of central stations rather block the introduction of motors because they are trying to invent one themselves, or have a friend round the corner at the same work." The best arrangement of a motor will only be found by experience. In some cases it will no doubt be found possible to dispense altogether



demanded. For such work a motor thus fitted seems to be very useful, especially in driving milling machines, which are now gradually replacing other machine tools for many classes of work; and for polishing wheels the electromotor, applied in this way, seems to possess advantages over geared motors. For tools of this class, freedom from vibration is essential to good working, and high speeds are often requisite in dealing with certain materials; both of which *desiderata* can, in all probability, be supplied by a direct-coupled electromotor more perfectly than in any other manner. By means of a switch and resistance coils, the speed can be more or less economically reduced, but there is no possibility of altering the power as is done by the ordinary speed pulleys, unless these are retained and driven by the motor. It will be noticed that the traversing shaft in this lathe is driven by a belt and speed pulleys. If pulleys and belts are to be used for driving the main shaft of a machine, the building of the motor into the frame work is not so important, and we come back to the method adopted at Wolverhampton, Liège, Charlton, and other well-known examples of electrically-driven factories.

The small amount of power taken by machine tools must be measured to be believed, and no better way of measuring it is possible than with a motor, an ammeter, and a voltmeter. For American work especially, where one tool is kept to one kind of work, and where large quantities of work are turned out with little or no variation, it ought not to be difficult to select the right size of motor to give the best result. For jobbing, with overhead gear and belts, and to drive direct, as has been done in ship-building tools, drills, and the lathe fitted by Mr. Wheeler.

THE ACTION OF ELECTRICITY ON THE CARBURATION OF IRON BY CEMENTATION.

An interesting process has been devised by M. Jules Garnier for accelerating the carburation of iron. In the ordinary cementation process, the bars of wrought iron which require to be carburised are packed in layers in a mass of powdered carbon, and are sustained at a bright red heat for a time which depends on the size of the bars, and on the extent to which they have to be impregnated with carbon. Slight case-hardening will usually occupy only a few hours, while the complete production of blister-steel bars from merchant or puddled bar will take from ten to fifteen days. During the whole time, the stack must be kept at a high temperature, at, of course, a considerable expense in fuel. Blister steel is used to some extent in the arts, while case-hardening is largely resorted to in mechanical and electrical engineering; so that any modification of the process which will reduce the consumption of fuel, or accelerate the process, will be of no small importance.

It occurred to M. Garnier, whose experiments have been communicated to the *Académie des Sciences* by M. Moisson,

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that it might be possible to increase the activity of the process of cementation by means of the electrolytic action of a current, using an anode of carbon and a cathode of the iron to be carburated, the electric current being passed while both cathode and anode were maintained at furnace temperature. To test this, a rod of carbon and a bar of extremely mild steel (0·1 per cent. of carbon) were placed end to end, and well insulated from one another, in a tube or barrel of some refractory material. This was then placed horizontally in a reverberatory furnace, heated by a blast of air supplied from underneath. While thus kept hot the carbon rod was connected to the positive, and the iron bar to the negative, pole of a Gramme machine capable of supplying a large current at low pressure.

A current of 55 amperes under a pressure of 7 volts was maintained between the carbon and the iron for three hours; after which the bar of iron was quickly taken out of the furnace and instantly plunged into cold water. The end of the bar which had been opposite the carbon rod was now able to scratch glass very strongly, and when it was ground to a bevelled edge at an emery wheel, it indicated that cementation had taken place to a depth of 10 mm. On repeating the experiment, but with a mild steel bar in place of the carbon rod at the anode, and a similar bar at the cathode, it was found that, while the anode was not hardened nor modified in the least, the cathode was strongly carburated by the electrolytic impregnation of carbon.

It would thus appear that one at least of the advantages to be derived from the application of electricity to the manufacture of blister steel is the immense saving in time occupied by the process, by which the annual output of each furnace can be very largely increased and the cost of plant and stock can be reduced. If at the same time it can be shown that the cost of the electrical energy used is less than that of the fuel which must otherwise be consumed, and if there is any possibility of modifying existing stacks to suit the new process, the electrolytic method of producing blister steel ought to stand a good chance of rapid introduction on a commercial scale.

THE CONDITIONS DETERMINATIVE OF CHEMICAL CHANGE.*

BY PROF. HENRY E. ARMSTRONG, F.R.S.

Notwithstanding the large amount of evidence now placed on record that substances commonly supposed to be capable of directly interacting do so only in the presence of at least one other substance, chemists do not appear to have arrived at any clear and consistent understanding of the conditions determinative of chemical change: as each fresh case is recorded we continue to express surprise, overlooking the fact that Faraday, in his early "Experimental Researches in Electricity," clearly foresaw what the conditions were, and that but a slight extension of his generalisations is needed to frame a comprehensive theory. The subject is of such importance that it appears to me desirable to discuss the bearing of recent observations, especially as they to some extent necessitate the modification of views that I have expressed elsewhere, and in order to attract the attention of physicists, to whom we must now look for guidance in these matters.

Eight years ago, in the course of the discussion on Mr. H. B. Baker's communication on "Combustion in Dried Gases" (*Chem. Soc. Proc.*, 1885, p. 40), I defined chemical action as *reversed electrolysis*; in other words, in order that chemical action may take place, it is essential that the system operated on comprise an electrolyte. I then pointed out that as neither hydrogen nor oxygen was an electrolyte, a mixture of only these two gases should not be explosive; and, moreover, that as water was not an electrolyte, and it was scarcely probable that water and oxygen or hydrogen would form an electrolyte, it was difficult to understand how the presence of water pure and simple should be of influence in the case of a mixture of hydrogen and oxygen. This forecast has since been verified, the remarkable series of experiments carried out by V. Meyer, in conjunction with Krause and Askenasy, having clearly demonstrated that the formation of water from hydrogen and oxygen takes place at an irregular rate, and is, therefore, dependent on the presence of a something other than water—I imagine an acid impurity. But this is a consideration which has not yet received the proper attention, and it is, therefore, desirable to emphasise its importance by reference to other cases. Mr. Baker's recent preliminary note on the influence of moisture in promoting chemical action (*Proceedings*, p. 229) affords several interesting examples. Thus, he states that neither does hydrogen chloride combine with ammonia, nor is nitric oxide oxidised by oxygen if moisture be excluded. In the former case, the addition of water should suffice to determine the combination, as water and hydrogen chloride together form a "composite electrolyte" (*cf.* Roy. Soc. *Proc.*, 1886, No. 243, p. 268). As neither nitric oxide nor oxygen, however, forms a composite electrolyte with water, in this case water alone should not determine the occurrence of change; but if by the introduction of a trace of "impurity" in addition to water the presence of a composite electrolyte were secured (however high its resistance, owing to the smallness of the amount of "impurity"), action would set in, and when once commenced would proceed at an increasing rate, as nitric acid would be formed and the resistance of the electrolyte would consequently diminish. On this account it will be a task of exceeding difficulty to experimentally demonstrate that nitric oxide and oxygen are inactive in presence of water alone; but there can be no doubt that such must eventually be admitted to be the case, provided always that it is permissible to extrapolate Kohlrausch's observations, and to conclude from them that *pure* water is a dielectric. The gradual increase in the rate of change here contemplated corresponds to the period of induction observed by Bunsen and Roscoe in their observations on the interaction of chlorine and hydrogen; the statement recently made by Bodenstein and V. Meyer (*Berichte*, 1893, 1,146) that a mixture of chlorine and hydrogen behaves irregularly on exposure to light is a valuable confirmation of Pringsheim's observations, and there is now no room for doubt that *pure* chlorine and hydrogen would be incapable of interacting. That no such irregularity is observed on heating iodine with hydrogen is not surprising, as hydrogen iodide would be formed from the very outset and the electrolyte present would exert a minimum resistance almost at once. There is, however, a significant difference in the behaviour of the two mixtures, as hydrogen chloride should behave as hydrogen iodide, so that the problem is but incompletely solved; it may be that the one mixture was more nearly pure than the other, or it may be that the formation of hydrogen chloride from hydrogen and chlorine, under the influence of light, is dependent on the presence of some particular substance, together with water, and does not take place under the influence of any substance capable of forming a composite electrolyte with water; probably, however, the difference observed is chiefly due to the fact that only one of the actions is reversible under the conditions prevailing in the experiments.

Lastly, attention may be directed to the formation of sulphuric oxide from sulphurous oxide and oxygen, which is readily effected in presence of a catalyst, such as finely divided platinum; it cannot be supposed that the mere presence of platinum would condition the occurrence of change, and doubtless moisture is also necessary, the platinum or other catalyst but serving to promote the oxidation of the sulphurous oxide at a temperature considerably below that at which sulphuric oxide decomposes when heated. The action of surfaces generally may well be of this character, and the converse influence they so frequently exercise is probably an effect of the same order.

I have elsewhere raised the question whether there may not be a difference between actions taking place under the influence of low and of high electromotive forces—whether water, *per se*, may not be an electrolyte towards high, although not towards low, forces in the case of high temperature changes, or those brought about under the influence of the electric spark, for example. More attentive consideration of the subject has led me to think that this is not the case, and that we must treat high temperature changes such as occur and are involved in gaseous explosions in the same way as those occurring under ordinary conditions and at low temperatures. From this point of view, Mr. Baker's statement that ammonia and hydrogen chloride do not combine is of extreme importance; the formation of ammonium chloride from these two compounds apparently involves no interchange, but a mere combination of two substances each endowed with considerable "residual affinity," and there is no reason why a distinction should be drawn between such a case and that afforded by, say, *atoms of hydrogen and oxygen*, the difference being, it would seem, one of degree only: in fact, I am no longer inclined to believe that atoms are capable of directly uniting. In all cases at least one function of the (composite) electrolyte would appear to be that of providing the necessary "mechanism" whereby the degradation or discharge of the energy is effected. If this argument be sound, its logical extension involves the conclusion that *pure* gases should be dielectrics, *i.e.*, that the passage of an electric discharge through a gas like that of an explosive wave through, say, a mixture of hydrogen and oxygen, can only take place if an electrolyte be present. Hitherto but little attention has been paid to the electric discharge in gases which have been highly purified. The peculiar behaviour of Tesla tubes, referred to by Mr. Crookes in the discussion on Mr. Shenstone's Paper on the formation of ozone, is, perhaps, explicable from this point of view. It may be that the atmosphere within the

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tube does not become conducting until sufficient moisture and "impurity" have been projected from its sides. It is conceivable that a similar explanation may hold good in the case of Prof. Schuster's observation, that it is possible to urge a current of low electromotive force across a gas subjected to a high electromotive force in itself insufficient to cause a discharge in the gas; the atomic dissociation hypothesis put forward in explanation of the phenomenon does not appear to me to be sufficient.

Finally, the question arises, Can no line be drawn; are no two pure substances capable of combining or interlacing, for example, water and sulphuric anhydride? There is little to guide us here, but it seems not unlikely that water has special properties which enable it to act directly; moreover—perhaps because—in such cases composite electrolytes would result. Ammonium chloride, so long as it remains solid, is clearly a compound of a different order, and it may well be that compounds of this type are in no case directly obtainable from their constituents, because, under the conditions under which they are formed, they cannot behave as electrolytes.

Apparently, in all cases in which molecular aggregates are formed—as in the case of solutions—we are dealing with dissociable and dissociating systems, and it is not improbable that we may ultimately find an explanation of the mechanism of such changes in this fact.

At present there is no information forthcoming whether simple electrolytes, such as fused silver chloride, for example, will condition chemical change in the way that water does; whether, for instance, silver chloride will condition the formation of hydrogen chloride from chlorine and hydrogen, so that a gas battery might be constructed of these three substances.

THE NATURE OF DEPOLARISERS.*

BY PROF. HENRY E. ARMSTRONG, F.R.S.

When an electric current is passed between plates of platinum through a solution of sulphuric acid, the hydrogen and oxygen are partly retained at the surfaces—and apparently also within the plates—and under these conditions are capable of interacting, as in the well-known Grove gas battery; so that in so far as the "gases" thus circumstanced are concerned the change may be expressed by a reversible equation. This reversal constitutes the well-known phenomenon termed polarisation by physicists.

Reversal owing to the retention of hydrogen in circuit is promoted to different extents by different metals—hence apparently the varying electromotive forces of single fluid cells containing different negative plates; and when the pressure is sufficient to retain the whole of the hydrogen at the plate, it becomes total—hence it is, for example, that zinc does not dissolve in sulphuric acid under great pressure.

Various substances known generally as depolarisers are used to prevent the accumulation of products of electrolysis and the consequent reversal of the action—such as copper sulphate in the case of the Daniell cell, and "nitric acid" in the case of the Grove and Bunsen cells; but whereas the action of copper sulphate is easy to understand, that of "nitric acid" offers many difficulties. As the heat of dissolution of copper in dilute sulphuric acid is a negative value (about 12,000 units), the displacement of copper by hydrogen—*i.e.*, the heat of dissolution of hydrogen in copper sulphate—is a positive value, so that not only does the presence of the copper sulphate prevent the accumulation of hydrogen, but in removing hydrogen it also serves to increase the electromotive force of the cell from about $\frac{7}{8}$ths to about $\frac{7}{8}\frac{9}{0}$ths of a volt. The principle underlying this is extensible even to cases in which one part of the cumulative effect of the cycle of change is a negative value. Thus, although copper has a negative heat of dissolution, it will readily dissolve in dilute sulphuric acid if it be used in place of zinc in a Grove cell, the negative heat of dissolution of copper being more than compensated for by the positive heat of dissolution of hydrogen in "nitric acid"; and it is well known that copper dissolves in many weak acids in presence of oxygen. It is easy to understand how oxygen acts in such cases, but the facts show that the effect produced by "nitric acid" is not so readily interpreted, and their consideration raises important questions of general application.

Russell has shown that when "nitric acid" is freed from nitrous compounds it does not dissolve silver, but that action sets in when a trace of nitric oxide is introduced, and continues with increasing rapidity as the quantity of the nitrous compound—a necessary product of the action—increases; Veley's later experiments have shown that the same is true of copper, without, however, affording any further explanation of the phenomena. Although it is not to be expected that such metals would dissolve in nitric acid even when coupled with a relatively electro-negative conductor, as they have negative heats of dissolution; yet, if the acid also acted as depolariser, a cycle might be formed in which sufficient energy would be developed to condition change. It therefore follows that in such cases *nitric acid* does not act as the depolariser in accordance with the equation: $2Ag + 2NO_3H + ONO_2H = 2AgNO_3 + H_2O + NO_2H$, and that, in point of fact, the nitrous compound is the depolariser, although the nitric acid is the actual solvent of the metal, the hydrogen of the acid being virtually directly displaced by the metal with the assistance, however, of the current energy derived from its own oxidation by the nitrous compound.

But what interpretation is to be given of the behaviour of more active metals, such as zinc, magnesium, &c., which have positive heats of dissolution, and, therefore, are capable of dissolving in the pure dilute acid if coupled with a relatively negative conductor. Does nitric acid in their case directly act as depolariser? If it be capable of thus acting, such metals, even when uncoupled, should dissolve in the pure diluted acid. It is noteworthy that when such metals are dissolved in nitric acid hydrogen is sometimes evolved. It has been suggested that this hydrogen is derived from the interaction of the metal and water, but I cannot now regard this as a probable explanation; its production serves rather to suggest a deficiency of the depolarising agent, which cannot well occur if nitric acid be the depolariser. Indeed, if nitric acid be regarded as directly active, it is remarkable that in presence of the large excess of the acid which is always present any hydrogen should escape; and also that the reduction should extend so far as it often does, and not extend merely to the formation of nitrous acid. If, however, the acid be incapable of directly acting as depolariser, and a nitrous compound be the initially active depolarising agent, it is no longer surprising that, owing to the nitrous compound suffering further reduction, it should be deficient in parts of the circuit, and that, consequently, hydrogen should escape. Why the reduction should extend so much further when metals having positive heats of dissolution are used, however, still requires elucidation.

In the case of sulphuric acid, whatever metals be dissolved in the *diluted* acid, no reduction takes place; and it is only when the concentrated, and more or less heated, acid is used, that sulphurous oxide and other reduction products are obtained. It appears not improbable that reduction only takes place under conditions under which the presence of sulphuric *oxide* is possible, *i.e.*, that depolarisation is effected by sulphuric *oxide*, and never by sulphuric *acid*, although this latter may be regarded as the actual solvent of the metal. There is at present no evidence forthcoming to show that nitric acid can dissociate into the anhydride and water, and even if such a change took place in concentrated solutions, there is no reason to assume that it can also take place in dilute solutions, and that this is the explanation of the difference between nitric and sulphuric acids. It is well known, however, that nitric acid is resolved with extreme facility into nitrogen dioxide, water and oxygen, and that it is excessively sensitive to the action of nitric oxide—a trace of nitric oxide would therefore exercise a fermentative action and condition, the formation, it may be, of nitrous acid, or—as there is no evidence compelling us to suppose that the compound represented by the formula HNO_2 exists—it may be of nitrogen dioxide.* In this latter case, solutions of nitric acid would resemble concentrated sulphuric acid in containg a reducible oxide, and it may be that their depolarising action is initially exerted through such an oxide alone.

To arrive at a clear conception of the function of acids in dissolving metals, and of the nature of depolarising agents, it would, therefore, appear to be necessary to take into account many circumstances to which hitherto but little attention has been paid.

* Reprinted from the *Proceedings* of the Chemical Society.

The Claude Phasemeter.—At the recent exhibition of the Société de Physique M. Claude showed an instrument for measuring the difference in phase between the current in a circuit and the impressed electromotive force. The principle of the instrument is as follows:—When a piece of soft iron, fixed to the end of a spring, is placed before the pole of an electromagnet having a permanently magnetised core and traversed by an alternating current, it is attracted and vibrates with the same period as the current. If the spring also carries a mirror from which a ray of light is reflected on to a scale, the length of the band of light produced will be proportional to the maximum displacement of the mirror. Two such electromagnets are used, acting on the piece of soft iron in opposite directions, and at such distances that they produce the same maximum deflection, one magnet being placed in series with the circuit, and the other joined to the ends of a non-inductive resistance. Under these conditions, the length of the band of light is proportional to the cosine of half the angle of lag.

* $NO + 2\,HNO_3 \rightleftarrows 3\,NO_2 + H_2O$.

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(The Oldest Electrical Journal.)

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.
Editorial, Publishing, and Printing Offices :
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.
Telephone No. 2714. Telegrams: "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed "Coutts and Co."*

All Editorial letters to be addressed to the Editor.

All letters intended for insertion in "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as evidence of good faith. No notice whatever will be taken of anonymous communications.*

THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. It is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvenders; or direct from the Publishing Offices.*

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THE NATIONAL TELEPHONE COMPANY v. THE ELECTRICAL INDUSTRY.

The Joint Committee of the Houses of Parliament which has been giving close attention to a large body of evidence for seven days, has had to consider much wider subjects than that for which it was summoned. The Committee was appointed at the instance of an application of the National Telephone Company, who felt that the time had come when they might make a powerful attack on all those who obtain statutory powers for using electrical energy. They sought to impose, by the assistance of Parliament, most onerous prohibitions and restrictions on any body who might accidentally inconvenience them. Practically the whole electrical engineering industry of the country was mercilessly attacked for the ends of one monopolist, and this not because its telephonic monopoly was in any way threatened, but because the imperfections of its single-wire system were likely to be brought to light.

The Telephone Company, employing as they do the most delicate instrument known to science, as far as varying or alternating currents are concerned, spread over the land a web of wires which are poorly adapted to their ostensible purpose of enabling conversation to be carried on, but which could hardly be better adapted to pick up every stray current or any inductive effects that might be present. If the Company, instead of attempting to crush all who annoyed or might annoy them, had agreed to compromise in a friendly way, on any of the many occasions when compromise has been suggested (as for example at the London Chamber of Commerce), some arrangement might have been suggested whereby a traction company might have increased the size of its return conductor, or have rearranged its feeders, or have

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contributed towards the expense of altering any telephone wires which were actually disturbed. But such compromises are never attractive to monopolists. We do not complain of monopolies; they do excellent service, and service that could not otherwise be rendered so efficiently; but scratch a monopolist and you will find a tyrant.

The evidence placed before the Committee, as far as the telephone interests were concerned, dealt chiefly with leakage, insulation, and earth currents. One or two witnesses for the traction companies vainly tried to call attention to the effect of induction, but here the deficiency of the single-wire telephone circuit is so palpable, and the remedy so obvious, that the Telephone Company said but little about it. Curiously enough, the Plymouth Clause, the essential portion of which was printed on page 68 of our present volume, alluded to "injurious interference by induction or otherwise." The question of induction remains practically where it did before the Joint Committee sat. Not one of the high scientific authorities who were retained by the Telephone Company ventured to suggest any way in which an electric tramway could be erected so that a neighbouring single-wire telephone line should be undisturbed by induction. The National Telephone Company does not appear to care a rap whether this is scientifically possible or not, as their procedure at Salford and elsewhere plainly shows.

The question of leakage gave rise to two other inquiries: one, as to the electrolysis of buried pipes and conductors, which in no way affected the telephone interests, unless by adding to the difficulties which their opponents had to face; and the other, concerning railway telegraph signals. The provision of a metallic return for railway signals is, of course, a proper precaution. Mr. ASPINALL'S estimate of £48,000 outlay, and £7,700 a year maintenance is quite inexplicable; for a single return wire within a mile or so of the disturbance is all that is needed. Duplication of each wire seems to be, in many cases, not only unnecessary, but likely to lead to great complication. To the cost of such a return wire, a traction company might fairly be asked to contribute. Experiment would easily show how far disturbances are likely to extend; Mr. PREECE puts it at from half a mile to a mile. The sudden impulse due to a short circuit is to be feared rather than the working current. The electrolysis question appears to be the real matter of importance, although Mr. CROMPTON, speaking probably from an electric lighting point of view, says that it has been greatly exaggerated. In our leading article of March 24th last we alluded to the serious consequences which might result from a continuous passage of currents through the earth, and we have not hesitated to give the fullest publicity to various instances of electrolytic corrosion that have occurred. The earthing of the negative pole and proper regulation of the fall of volts on the return conductor ought to be a sufficient cure for traction work as it has been for electric lighting. Just at the time when the discussion on "earthing the middle wire" was being carried on in our columns, several engineers were becoming assured that the precaution which they had for some time adopted, of earthing their negative, was giving such good results that they could not contemplate the earthing of the middle wire. We could not get any of them at that time to definitely express their views in our columns, but this opinion may well be recorded on the present occasion. The evidence of Major CARDEW was of great interest and importance. He described the result of several accidents, but all of these, together with one mentioned by Dr. J. HOPKINSON, were due to actual contact. Even the ringing of the electric bell at Clapham-road was shown to be, in all probability, due to actual contact and not to stray earth currents. It still remains to be proved that any appreciable electrolytic corrosion is due to pure conduction through the soil; scientifically it is possible, but it is not yet within our experience. If a difference of six or eight volts is maintained at the ends of an earthed conductor, it is clear that, theoretically, corrosion should take place at the anode end. Major CARDEW makes the very reasonable suggestion that as the Board of Trade restricts the fluctuation of pressure on electric supply mains to three per cent. from the standard, they might, in an analogous way, restrict the drop in volts on an earthed conductor. This restriction would probably have been made sooner or later, and we have to thank the National Telephone Company for having given an opportunity for its discussion before any accident has made it a necessity. Major CARDEW said that he had made an examination of the condition of the line at Leeds, and intended to go there again, to see how the arrangement had worked after a year's interval. We understand that he has had the ground opened at several places, and has found no sign whatever of corrosion. Prof. DEWAR'S evidence was of a more theoretical nature. He fears that the polarising film of hydrogen which is supposed to protect buried pipes when connected to the negative pole, would combine with the nitrates in the soil, and that corrosion, presumably by the formation of nitric acid, would take place. How this could occur while the metal was still a cathode is not easy to see. It is perhaps a pity that Major CARDEW and the experts were necessarily unprepared for discussing this important question, but it is possible that had notice been given, the practical suggestions would have been swamped by a mass of theoretical considerations.

The report of the Committee will be awaited with interest. It is very unlikely that the cool demand of the National Telephone Company for the continued insertion in all Tramways Acts of the Plymouth clause will be granted unconditionally; if they wished to continue to get such clauses inserted as heretofore, it would have been better to have let the matter rest where it was. It is likely that a recommendation will be made to give them powers to go underground; but they will also be expected to take some steps to modify the crude and deficient system of lines which have led to the inquiry. The railway question should be easily settled, and details of railway construction being already under the immediate control of the Board of Trade, no difficulties need be apprehended. Some of the suggestions made by Mr. PEMBER in his speech, an abstract of which will be given in our next issue, were rather amusing. It might be enacted, "that in no case should a current be sent to earth (never mind who by) greater than some ascertained fraction of an ampere;" "it might be enacted that two wires should be laid so near as to prevent induction;" and "that it should be a sufficient compliance with the Act if the promoters, in constructing and maintaining their works . . . adopt the best-known means of insulating the conductor . . . ." We venture to suggest quartz pedestals and annular sulphuric acid cups as suitable for this purpose. We can sympathise with the National Telephone Company in the unfortunate quality of the work which they bought from the early companies, and the unproductive character of much of their capital; in the heavy royalty which they pay to the Government, which is certainly more in the nature of a fine; in their expensive way-leaves, and their uncertain tenure; in their inability to obtain statutory powers to go underground—overhead powers are another matter; but we cannot sympathise with their attempt to obtain protection for their imperfect system, which not only gives inefficient results, but has been used to retard the progress of other electrical industries.

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ELECTRICITY AT FÜRSTENFELD-BRUCK.

The electrical utilisation of water-power is making far greater progress on the Continent than with us, owing, no doubt, largely to natural conditions. Whilst large transmissions have more interest for the engineer, it is the smaller applications of water-power to the generation of electricity that have the most social interest. Few localities have a Niagara at their disposal, but the towns and hamlets that could impress the services of a small amount of horse-power are numerous, even in the United Kingdom. It is from this point of view that it is well to occasionally take note of what small Local Authorities are

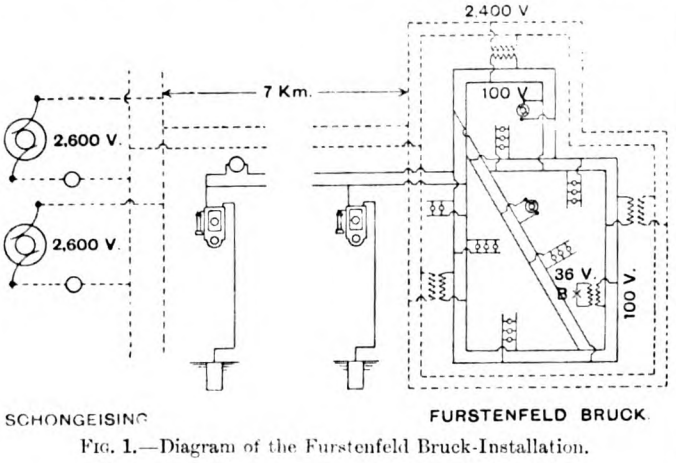

FIG. 1.—Diagram of the Furstenfeld Bruck-Installation.

doing on the Continent in the direction of utilising by means of electricity the hitherto wasted power of streams and rivers. We, therefore, take the following particulars with regard to a water-power installation from a well-illustrated little pamphlet sent us by Herr Oscar von Miller.

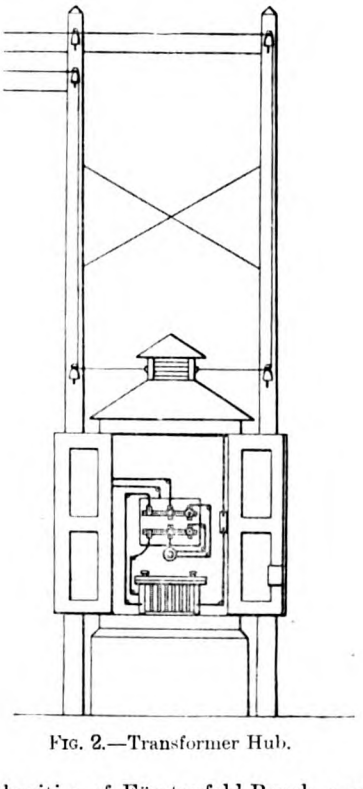

FIG. 2.—Transformer Hub.

The local authorities of Fürstenfeld-Bruck, a quiet Bavarian town of about 3,000 inhabitants, having purchased a mill site with a view to waterworks and an electric lighting station, called in Herr von Miller to carry out the electrical part of the work. The power station at Schöngeising, 4½ miles off, contains at present two knop-turbines driving on to a common shafting through bevel gear; there is room and sufficient water for a third turbine when required, making in all 180 H.P. From the countershaft are belt-driven two Brown-Boveri 2,600-volt alternators, and an exciter. Herr von Miller remarks that he chose the "single-phase alternate-current instead of the 'Drehstrom,' so much talked about of late, and first applied by myself at Heilbronn, because the latter requires three wires, and it is highly desirable, especially where we have overhead lines, to keep down the number of wires as much as possible." The turbines are governed by hand manipulation of the sluice-gates, and by an automatic governor which puts on the brake if the speed exceeds the normal.

The 2,600-volt current is carried to the outskirts of Bruck by 6mm. wires. A high-pressure ring main is carried right round the town (*see* Fig. 1), and to this a low-pressure (100 volt) network is connected by means of 10 oil-transformers placed at intervals in huts, having the external appearance of a sort of glorified letter-box (*see* Fig. 2). The low-pressure network has a total length of some four miles. When the high-pressure wires reach the limits of the town the height of the poles is increased, and where possible the wires are taken over the house-tops.

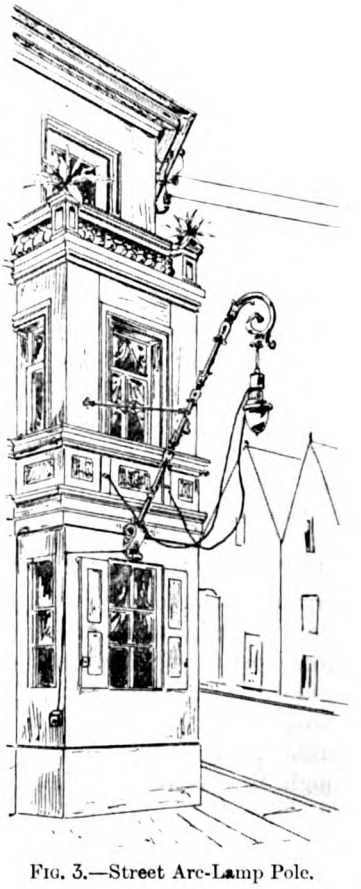

FIG. 3.—Street Arc-Lamp Pole.

With the two machines at present available, and allowing for a 17·5 per cent. loss in the line, transformers and low-pressure network, the station can supply current to some 2,600 simultaneously-burning 8 c.p. lamps or their equivalent, so that over 3,000 lamps may be connected up without fear of overloading. At present 1,500 glow lamps and seven arc lamps, distributed amongst 70 houses, are in use, in addition to 12 motors having a total of 18 H.P. These twelve motors assist at a varied assortment of operations; one helps to winnow corn, another assists the work of a soap-boiler, whilst a 5 H.P. motor has quadrupled the output of a carpenter's shop. The local agricultural club have on order a portable thrashing machine, which they intend to have driven by electricity. When we consider the price asked for the current and the method of charging, the extensive use of current (which has only been available for a few months) is no longer a matter for surprise. The total first cost of the present installation was £3,000, and Herr von Miller, being of opinion that it is more becoming to a municipality to encourage a general use of electricity than to make a "good thing out of it," decided to recommend the adoption of a very favourable tariff. Each consumer has to state the maximum current he is ever likely to require, and

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an appropriate fuse having been inserted in the service main, he is charged 20s. per 16-c.p. lamp, or its equivalent, per annum. Taking private-house lights as likely to be burnt under these conditions, on an average 800 hours per annum, the cost of the 8 c.p. lamp-hour works out at 0·16d., whilst if we take a one-horse motor as the equivalent of 18 16-c.p. lamps, its cost for current will be £18 per year of $365 \times 24 = 8{,}760$ hours. As Herr von Miller points out, a method of charging of this kind is by far the best where water-power is concerned. It saves meters, with their unpleasant surprises for consumers at the end of each winter quarter; and since a river refuses to stop flowing until the sun sets, unless expensive dams and weirs are used, it may as well be made use of, and by granting the lowest tariff compatible with a moderate profit and the payment of working expenses, interest, depreciation, and repairs, the employment of motive-power is encouraged, and water which would otherwise run to waste is utilised; the working expenses of the station being increased only by an inappreciable extra amount of wear and tear, and a little larger consumption of oil and waste.

The motors are worked off transformers, the sudden rush of current on starting being prevented by gradually switching in extra coils on the motor or secondary circuit. A large portion of the building and line work was carried out by local workmen, who, amongst other things, were responsible for the street arc lamp supports, which, as will be seen from Fig. 3, have the advantage over our London ones of originality, and of being out of the way, although it must be admitted they do not so very remotely resemble barbers' poles. It may be mentioned that the technical staff of the Fürstenfeld-Bruck municipal central lighting station consists of two turbine and dynamo tenders at Schongeising and a works manager at Bruck. No reserve of steam-power is provided at Schöngeising against periods of extraordinary low water, Herr von Miller being of opinion that the best, not to say the cheapest, reserve are the disused petroleum lamps and farthing dips. It may be mentioned in this connection that the Castle of zur Post at Bruck has a yearly lighting bill of £20, which is exactly the same as was formerly paid for less light from petroleum lamps.

PARLIAMENTARY INTELLIGENCE.

THE ELECTRIC POWERS PROTECTION CLAUSES.

The evidence before the Joint Committee was opened by Sir Courtenay Boyle, as reported in our last issue. In stating the case with great impartiality he displayed a much more intimate acquaintance, not only with the general conditions of electrical traction and telephony, but with the electrical details, than might be expected from the chief officer of so extensive and miscellaneous a department as the Board of Trade. Mr. Preece following, introduced perhaps rather too much pure science when he alluded to that which was "commonly called induction, but which was now explained to be due to the passage of electromagnetic waves through the ether which fills all space." On the other hand, he said that the earth currents spreading from the City and South London Railway over the neighbourhood "give rise to a great waste of energy." If the current were confined to the return conductor and the tube, the resistance would be higher than at present; so as far as expenditure of energy is concerned earth leakage is an advantage. A more serious mistake, fortunately detected and set right by Lord Russell was that these earth currents "extend as far as Norfolk." A few Leclanché cells can easily, and do indeed every day, give rise to currents which "extend as far as" from England to America, for the simple reason that there is an insulated wire to carry them; and if there were not they would not go. Considerable disturbance seems to have been wrought in many editorial minds by this bit of evidence. The *Evening Standard* thinks that the evidence given by Mr. Preece was "not a little awful"; and many other papers show signs of believing that the City and South London Railway sends electric currents *through the earth* "as far north as Walsham, in Norfolk." During the early sittings of the commission the "accidental" and the "intentional" use of the earth was frequently alluded to; the expressions were unfortunate and seemed to introduce ambiguity. The National Telephone Company made a very good case as to their extensive and cheap service, but the comparison between their charge for a "message" and the average charge by the Post Office for a telegram is quite illusory. If big differences are wanted, why not estimate the cost per word, making a special reduction for "Are you there?" and "Speak up, can't you?" The suggestion made by two witnesses of stopping the whole telephone system of Liverpool for five or six years if electrical traction were introduced there, was too absurd for such sensible men as the members of the committee. Lord Cross quickly disposed of it on the second occasion. Curious exaggerations were as common here in the evidence of the experts as they are in the Law Courts. Sir Frederick Bramwell estimated the extra cost of a metallic overhead return—a double trolly system, in fact, as at Cincinnati—as only 6 per cent. more than that of a single line. The Committee had the pleasure of gazing day after day, after this, at a large model of a junction on the double trolly system, an excellent object lesson on the complications and expense of the method. Another rather curious piece of evidence was introduced, apparently from the evidence given on the projected Clapham Junction and Paddington Railway, that a certain magnetometer was 70 times more sensitive than a certain microphone. Both instruments are well adapted to measure disturbances due to electric traction, but these disturbances are totally different, and are not comparable. Purely magnetic disturbances are of very little importance, and magnetic disturbances arising from stray currents are not very reliable for use in measuring the currents. Mr. Swinburne and Mr. Crompton were the only two witnesses who gave scientific evidence for the defence. Mr. Bennett, the only witness who was subjected to unpleasant cross-examination, gave evidence to rebutt that offered by the Telephone Company. After the evidence for the traction companies was closed by Gen. Webber, the electrical engineer to the Corporation of Blackpool gave some interesting information. The negative pole of the tramway has been put to earth for some time, and no trace of electrolysis has been found. After this an interesting group of experts in democracy were called: the town clerk of Walsall, the Mayor of Leeds, the Mayor of Salford, and a member of the Manchester City Council. These were unanimous, and expressed their opinions most emphatically, that telephones were all very well, they did not want to harm them, but they were of no importance compared to cheap traction, and they would readily abandon the telephones rather than impede the development of electrical traction. We have commented elsewhere on the evidence of Major Cardew and of Prof. Dewar. It may be said to only break the ground of a new and important inquiry which will no doubt be carried on by Major Cardew's investigations and tests. Sir Frederick Bramwell, appearing as he did for the gas and water companies, had no difficulty in arguing that insulated returns were the only remedy. A rather more easy line to adopt would be to say that electrical traction should be prohibited.

WEDNESDAY, JUNE 21, 1893.

Mr. D. SINCLAIR (Engineer-in-Chief to the National Telephone Company), examined by Mr. MOULTON, said that he had superintended the construction of the entire telephone system of Glasgow, which had 4,000 subscribers. The subscribers' wires there were on the single-wire system, and the trunk communication on the duplicate system. That arrangement had worked very well. Owing to the peculiar position of London, the main service there was not so good as in other towns, principally because London being such a large town it was, telephonically speaking, a series of large towns connected together; but, comparing it with Berlin and Paris, he should say that the service in London was better than in Paris and equally good with Berlin.

Mr. MOULTON: With regard to the duplicate system for subscribers' lines, what objections do you see to that?

The WITNESS said that scientifically there was no objection. Scientifically, the metallic circuit was better than the single wire, but when it became a commercial problem how to produce so much commercial result by a certain process, they had to take into consideration whether they could do it well enough with a single wire, or practically as well, as with a double wire. In many cases where permission would be given to carry a small number of wires, it would be withheld if the number were doubled, but if they had to duplicate their lines in any town the cost of the switchboards would be very great in addition. If they had 4,000 lines in an exchange, that meant that they must bring 4,000 contact points within the

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reach of an operator, which was confined to so many feet; therefore, if they had a greater number of lines into that place than the operator could reach to or along, then they made it impossible for the operator to work the switchboard. For each metallic circuit they would have to provide two jacks or points of connection, and if that was carried out to a large extent the space to which the operator would have to reach became so extended that they could not reach the top loft.

Mr. MOULTON: If any change was ordered, would it take any considerable time to make it?—Taking the town of Liverpool, there were 3,500 wires. If they had to metallic those overhead, the standards which carried the present wires would not be sufficient, so that it would mean sweeping down the entire system and building up a new system to carry twice as many wires. Inasmuch as it was impossible to work an exchange partly on the single and partly on the double on any large scale, they would have to make the change all at once.

The CHAIRMAN asked how it was done in London, because evidence had been given that in London the system was being exchanged at the present moment.

The WITNESS said that in London they were doing substantially what he had suggested. They were providing extra wires, so as to make the metallic circuit, but, with a few solitary exceptions, they were not yet put into operation, as they could not work the mixed system.

Mr. MOULTON: Practically these new wires will be idle until you can make the exchange?—That is so, and undoubtedly some will lie idle for years.

At this point Dr. HOPKINSON was recalled, by the request of the Chairman, to explain the actual action of electricity when it was once set to work in the telephones, and explained the manner in which the current was transmitted from the battery to the receiving instrument. Asked to explain exactly what he meant by the terms "current" and "transmission," he said he did not think anyone knew exactly what they were. He did not think anyone knew whether the energy which was transmitted for an electric current passed along the wire or through the medium which surrounded the wire. As to the electrolytic action, it had been found in America that pipes had been actually eaten through in consequence of it.

Mr. SINCLAIR'S evidence was then proceeded with, and in reply to Mr. Cripps, he said that at Glasgow at the present time, to a limited extent, they used the same exchange for metallic and earth returns. At Stockholm there was very considerable difficulty in working some telephones on one system and some on another. While in the case of the National Telephone Company *v.* Graff Baker he had said that the earth returns were capable of being worked in connection with the metallic returns, it was a question of degree. Up to 5 or 10 per cent. they could very well be worked together, but he understood they were now providing metallic switchboards at Stockholm, which bore out what he so strongly insisted upon, that when it became necessary to metallic the circuits, it became necessary to metallic the circuit all round. Asked whether the difficulty of reaching over the switchboard could not be met by having additional operators, he said the best and only system, which was used in all large exchanges, was to have only one operator.

The CHAIRMAN: I understand what you mean is this, you have a great number of operators, but each one of those operators is so placed that he or she can work every wire that comes into the place?—The Witness said that was exactly it. The largest exchange he had ever seen actually operated was 6,000, on the multiple system, so that they could imagine what it was, that the operator had 22in. or 23in. to sit in, and within her reach they had to bring the connection for 6,000 lines. The operator on the other side had also to reach 6,000 lines, though, of course, they borrowed from each other to some extent.

Mr. CRIPPS: Why should there be greater difficulty on the metallic system than on the earth system of one operator reaching all the points of contact? The Witness said that he did not contend that there would be greater difficulty, but the difficulty came in when they had a mixture of both. The reason greater space would be taken up was because they could not put 40 into a space which was made for 20.

By Mr. BALFOUR BROWNE: He did not agree with what Mr. Forbes (the Chairman of the National Company) said before the Telegraphs Committee, that in London, Liverpool, or crowded areas, the metallic circuit was absolutely necessary.

By Lord RUSSELL: A continuance of the present system of telephonic communication debarred any increase of electric traction.

By Mr. MOLLOY: He would not like to say that there was no leakage in the return current. It all depended upon the local conditions. If it was a good conductor from end to end, and there was less resistance than in the earth, there would be no leakage. What would be an absolute cure in one soil would be death to the telephone in a different soil. Under certain conditions there would less resistance in using a tube as the earth return than if the earth alone were used, but it depended largely on the nature of the earth. If the earth subsoil were solid clay, then that was the best condition. The tube used in the South London Railway was always in contact with the earth, and was practically an earth return. The leakage or induction used by that earth return had affected the telephonic system slightly from time to time, and now and again the result was serious but they were too busy to pay any attention to it, unless it became so serious as to interfere with the subscribers' use of the lines.

By Mr. FORWOOD: No legislation was required to give them wayleaves over houses, as they were private property. If legislation gave them rights over the roads, it would immensely facilitate telephonic expansion in London and other large places, and be a benefit to the public, the subscribers, and everybody all round. The tendency of having such legislation would be to cause the wires to be put underground. The first cost of a double set of wires underground would not be less than overhead, but the cost of maintenance would be less, and they would always know where they were and what they were doing.

Sir FREDERICK BRAMWELL, examined by Mr. WALLACE, believed that the exercise of the telephonic industry was absolutely without injury to any other industry of any kind, as the electrical currents were so extremely small. Having described the system of working the electrical cars at Leeds, Sir Frederick proceeded to say that the disturbance to the working of the telephones caused by the tramway was intolerable. In the Exchange, when the cars were at work, they lost as many words as they heard. He did not see why the traction companies should be placed in any better position than the electric lighting companies. There were no mechanical difficulties in the way of their having insulated returns. It could only be a question of expense, and that expense, he believed, compared with the whole cost of the line, was an extremely small percentage, and compared with the cost of duplicating the telephones, he should say it was not to be regarded. He thought he ought to tell the Committee that he was a telephone shareholder, and also an electric light shareholder.

Mr. BALFOUR BROWNE: But you have no tramway shares?—No tramway shares.

By Mr. BALFOUR BROWNE: Although he could tell how the metallic current arrangement could be done he could not tell where it had been done. At Leeds the disturbance was due to the induction or leakage or both, but he could not give any idea as to the amount of leakage taking place. He could give it in terms of annoyance, but not in amperes and volts.

By Mr. CRIPPS: Motive power was supplied by the electric lighting companies to a very slight extent. If the private telephone companies were treated in the same way as the official Post Office they would have all the protection that they wanted.

Mr. CRIPPS: Then you want the Telephone Company to have the same control over the electric traction companies that the Post Office and the Board of Trade have under the Electric Lighting Acts?

The WITNESS said he wanted the same in effect, but he did not know that they wanted it done in exactly the same way. The telephone companies were the agents of the Post Office, and paid 10 per cent. of the gross receipts, and he thought they therefore should be equally protected. They were a large public company doing a public service, and also endeavouring to make a dividend for their shareholders; and he did not think the latter point was inconsistent with their having proper protection.

Lord ROSSE: Have you formed any estimate of the extra cost which would be necessary in case of the tramways to give a metallic return?

The WITNESS said he had not figures before him, but he had formed a general estimate in this way: supposing they adhered to the overhead system, as in Leeds, to have a return overhead wire as well as an outgoing overhead wire, it was obvious that the extra cost was nothing but that wire. The outgoing wire at Leeds was $\frac{4}{10}$in. in diameter; that was not a very serious thing, because they had the whole structure ready to their hand to carry it. Taking the total expenditure on the tramway lines, with buildings, cars, and everything of the kind, he was quite certain that the extra cost of a metallic return could only be a very small percentage of the whole outlay—he should think it would be about 6 per cent. If the circuiting were doubled, the pressure or tension would be doubled.

Major DARWIN: I think you express a strong opinion in favour of the underground system of return wires in preference to the overhead system for tramways?—Yes.

Do you feel that just as strongly for country districts as for town districts?—Witness stated that he did not. Assuming the Telephone Company were told that if they wanted protection they must make it for themselves by doubling the metallic circuit; assuming also that the tramway companies were told, "You may send your current to earth"; assuming, then, that under those circumstances the inevitable accident occurred to the telephonic communication, and they went to earth by misadventure, then they were not protected from what was being done by the tramway companies.

By Lord ROSSE: For telephone purposes an overhead wire was much better than an underground one.

Mr. W. H. WINTERBOTHAM (Solicitor to the National Telephone Company) was examined by Mr. PEMBER as to the legal and Parliamentary controversies which had taken place with regard to the Company's position. As early as 1884 various Provisional Orders contained powers to tramway companies to use electricity, but as electrical traction was not a practical matter till within the last four or five years, they did not take any notice of it. In 1889, however, considerable strides having taken place in electrical knowledge, the question of electrical disturbance of the telephone lines was brought to their attention, and thereupon they took action to have protective clauses in the various Bills and Provisional Orders before Parliament. The Witness described the contests that arose during successive years, which led up to the more general adoption of the Plymouth clause, and out of 52 Bills or Provisional Orders which they had had to do with, the Plymouth clause had been inserted in 38, while others contained more or less stringent clauses.

By Mr. BALFOUR BROWNE: They were told that 200,000,000 messages were sent in a year, but he did not know that the number of people who travelled on tramways in the metropolis alone was three or four times that number. He agreed that anything that would interfere with electric traction would be a serious matter to the public.

Mr. FORBES (Chairman of the National Telephone Company) was then called. In reply to Mr. PEMBER, he said that the proposition that had been put forward was that it was impossible to conduct the telephonic system efficiently without a metallic circuit, and therefore the Company in their own interest and in pursuance of their duty to the public, were bound to use the metallic circuit; moreover, it was contended that great harm would then be done them by somebody else using the earth. To meet that argument he would submit several considerations. One was this: How much of the telephoning of this country, and of any other, was done on the metallic circuit? They were doing in this country 95 per cent. of the business on the earth-current or single-wire principle, and out of London and some other large centres they were doing their work efficiently

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and their subscribers, as far as they were aware, took into consideration the conditions under which the system had been developed. They knew, as a matter of fact, that from year to year complaints were being removed. He found that in certain places where the Post Office competed with them, despite the *prestige* attaching to a great public department, and despite the fact that the Post Office used a metallic circuit, whereas they themselves used the single-wire system, as a matter of fact their business progressed from year to year, and that of the Post Office remained stationary or diminished. That was tolerably fair ground for assuming that their system was the better of the two. He then gave statistics relating to the competition between the National Telephone Company and the General Post Office. These statistics, he said, were his answer to the suggestion that they could not conduct their business with such efficiency as to meet the public want unless they adopted the metallic circuit. He asked how they were to get their money back if they were obliged to apply the metallic circuit throughout their system; they were in possession of their licence for eighteen years and a-half, they had already spent a sum approaching to five millions of money, and they had got to get it back within that period. They certainly did not feel inclined to expend another million or a million and a-half for a mere fancy. He could not find any other reason for their remarkable development, except that the system which was thus proved to be an effective one was really the best system, and certainly it was the most economical. Whether they were expending State money, or private money, it was equally useless to spend it on what was not wanted. It appeared from the balance-sheet that the capital of the Company was £4,000,000, of which up to date they had spent £3,371,000 The income for 1892 was £463 741, or £100,000 more than in the previous year. The Post Office royalties were £54,000 or £55,000, and the dividend paid was 6 per cent. The Post Office had recently enunciated in a Treasury minute that they did not intend to grant new licences except under certain conditions, and he thought he had ascertained that they did not intend to grant them for any period longer than the extent of the National Company's licence, so he supposed it meant that at that time if the Government did not before exercise the power which they had of buying the telephones, they would have to restore them. Mr. Lamb, on behalf of the Post Office, had estimated the value of the Company's undertaking as it stood at the end of ten years at £1,000,000. If that were anything like true where was the difference to be got between £1,000,000 then and £5,000,000 now? It must be got out of the business. That was not encouraging to induce them to spend any more millions or hundreds of thousands of pounds, and as the years grew less it would militate against the expansion of the telephone business. He hoped that would impress the Committee with the extreme caution that the Company must exercise in doing useless things. If the common law right according to the Kekewich judgment was taken away by the action of Parliament giving unlimited powers to other bodies to put into the earth such a volume of current as destroyed the Company's business, and they were driven to spend a large sum of money in providing metallic returns, which were not wanted but for that, it would be a great hardship.

By Lord CLIFFORD: The objection to the underground system in London was that they could not get under the streets. They were at the mercy of every owner of property, some of whom would not let wires be placed over an entire estate, so that instead of going direct with a number of wires between two points, they had to find their way from one street to another, which caused a multiplication of exchanges. If they had power in London to use the streets as the Post Office or the gas and water companies use them, they could give an infinitely better service for London, because they could diminish the number of exchanges.

By Mr. BRUNNER: It had been thrown in the teeth of the National Company that they had bought up all the other companies. The 13 companies that had been bought had been bought up upon the very rational ground that if a telephone was to be conducted with economy and efficiency there must be some uniform plan of charge and control. To have 13 companies competing with them, one having its foot in one part of the country and another in another, would be as bad as the Irish railways.

Mr. PEMBER stated that that was all the evidence that he proposed to call on behalf of the National Telephone Company, and the case of the Associated Railways was then entered upon.

Mr. ASPINALL (Chief Mechanical Engineer to the Lancashire and Yorkshire Railway Company), examined by Mr. MOON, said that along the line of railway they had six different classes of wires, namely, block instrument wires, telephone wires, single repeater wires, Post Office wires (which they were asked to maintain for the Post Office), wires of their own for telegraphic purposes, and wires for sundry purposes connected with telephones for indicating purposes. Having described the purpose for and the manner which the various wires were used, he said that in August, 1891, they found that their instruments connected with the wires were being disturbed by the working of the Blackpool tramways, so that a line was indicated as clear when it was not clear, and when other trains were in the station. They had had disturbances before then, but had not been able to satisfy themselves that it was due to the action of the electric tramway until then. They found that while the disturbance continued throughout the day, it absolutely ceased when the tramway was not at work. The Railway Company considered that it was absolutely essential that they should have protective clauses given to them such as had been given by the Bolton Tramway Company. The clauses in the first instance provided that the Corporation should construct and maintain their electric circuit so as to prevent leakage and so forth. Before beginning to make their works they were to give notice to the Railway Company as to the nature of the works to be constructed, and the sort of current they intended to use; and the Railway Company were to make such requirements as they thought reasonable. By one of the clauses the Railway Company were to start at once and protect themselves as far as they thought necessary, the cost of doing so to be charged against the Corporation with reference to an arbitrator appointed by the Board of Trade, who would say whether what had been done was necessary, and whether the cost had been reasonable. The cost of doubling the wires on the Lancashire and Yorkshire system, so as to provide a metallic return, including the Post Office wires, would be £48,000, while the extra cost of maintenance, based upon the estimate which the Post Office already paid to them per mile for maintenance, would be £7.700 a year. Capitalising the maintenance charge at 33¼ years' purchase, and adding it to the cost of duplication, would represent to the Railway Company an expenditure of £305,000.

By Mr. BALFOUR BROWNE: Electric traction would affect them wherever electric tramways were started, and looking at the list which had been put in by Sir Courtenay Boyle, it showed so large a number of towns which were entitled to use electric power which were on their line that it alarmed them. They had such an intricate system of railway, and so many thousands of miles of wire, that they were really afraid of that system. Even with the expenditure of £48,000, they would not get absolute protection unless the tramway companies duplicated their circuit so as to prevent the possibility of leakage. Their signals had been altered by natural electricity during thunderstorms.

Mr. FLETCHER (Principal Assistant Electrical Engineer to the London and North-Western Railway) examined by Mr. MOULTON, described disturbances caused by electric traction employed by the South Staffordshire Tramways Company at Walsall. In order to protect their wires against the disturbance caused by the tramways, they had adopted the use of mechanical guards in addition to insulation, by which the evil had been cured.

By Mr. BALFOUR BROWNE: In order to do any injury to water-pipes there must be a difference of potential between the rail and the water-pipe; whether injury was done to the pipe depended upon whether the pole was negative or positive. The Railway Company had put down metallic returns in particular cases to avoid disturbance, in one case using a current up to about three amperes, and it was for the better working of that circuit to reduce the resistance.

The Committee then adjourned.

THURSDAY, JUNE 22ND.

Before proceeding with the evidence to-day, the Committee made an inspection of the National Telephone Company's exchange at East India-avenue, E.C., and at Oxford-court, E.C., and on their return to the committee-room the following witnesses were examined:—

Mr. WM. EDWARD LANGDON (Superintendent of the Telegraphic Department of the Midland Railway) examined by Mr. MOON, said that the signals of the Midland Company had also been affected by the operations of the South Staffordshire Tramways Company at Walsall to a distance as great as 3 miles 8 chains from the point where the tramway crossed the railway. The Midland Company ran through 32 of the 115 towns included in Sir Courtenay Boyle's list. In his opinion the only method to render the railway working safe was that such high currents as those used by the tramway companies should be entirely dissociated from the earth. Even if the railways protected themselves as far as they could by adopting metallic returns for their wires, that would not be sufficient protection unless they could ensure the insulation being always in a perfect condition. If they insulated the high currents from the earth in the first instance, and then insulated their own circuits from the earth in the second instance, then if anything went wrong with the high-current system they had another string to their bow. If they only duplicated their own wires, then if anything went wrong with their own wires the danger still existed. At Walsall he had duplicated each wire that was affected. He did not think that a single return being afforded for a number of wires would be at all sufficient. He would very much prefer giving each wire its own metallic circuit. He produced a block instrument, and explained its working to the Committee, stating that the Midland Company had 4,000 of them in use, and that the currents at Walsall affected the instrument so much as to carry the needle over to one side entirely. He considered that the Bolton clauses were the minimum that would be sufficient to protect the railway companies. The railway companies had no desire to impede electric traction; they would rather foster it than otherwise, and all that they sought was protection for the public traffic. No one had the right of monopoly of the earth: as telephone and telegraphic companies had the right to use the earth, and had not been dispossessed of it, those heavy currents if allowed to invade the earth would, of course, monopolise it, and would drive out all others that had connection with it.

Mr. HAMILTON: Supposing the effect of the Bolton clauses is to kill the tramways, have you no intermediate suggestion to make to the Committee between the death of the tramways and your clause?

The WITNESS replied that with him it was a question of public safety, and he could not depart from that position.

By Mr. WALLACE: The Company had 16,000 miles of wire, and he put the cost of duplicating one third of that down at £18,000. The additional cost for maintenance of the duplicated wires when capitalised would be £57,000.

By Mr. MOLLOY: The most effectual method of securing safety, as far as safety could be obtained, was to be found in the adoption of the metallic circuit, both for the tramways and for the railways. If it were only adopted by one or the other there would always be some danger from leakage, and they would only get half the protection. Dissociation from the earth on both sides was the only solution of the difficulty. As the question had been raised as to electrolysis, he desired to hand to the Committee an article which appeared in *The Electrician* on June 16th, 1893, on p. 172. This article had been written as to its effect on American railways.

Mr. SPAGNOLETTI (Electrical Engineer to the Great Western Railway Company) said that he had considered the best means of securing the safety of the public travelling on the railways in the event of tramway com

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panies using high currents for the purposes of traction, and was of opinion that the best system was that of insulated conductors for the incoming and outgoing currents. They might make some provision which would last for a time, but in order to have certainty the returns for the tramways must be insulated. If railway signals were insulated it would make it more sure, but that alone would not be sufficient to secure safety unless the tramway companies also adopted metallic returns.

By Mr. WALLACE: Electric lighting currents were very similar to those used for traction. He had experienced disturbance on the District Railway in October last which affected the whole of the working of the system between St. James's Park and Sloane-square, when it was found that the generating station of the Westminster Electric Supply Corporation had short-circuited. It would not affect the railways unless there was an accidental breakdown of that kind. Whether tramway companies should be put under the same restrictions as the electric light companies depended on the construction of the line.

By Lord ROSSE: The segments of the tube in the South London Railway were all bolted together, and there was a layer of cement between the earth and the segment of the tunnel.

By Major DARWIN: The electric light machinery at Westminster was some hundreds of yards from the point where the disturbance was felt on the railway. The whole line was deranged between St. James's Park and Sloane-square; but beyond that there was no disturbance to interfere with business. That showed that the area of disturbance extended over some hundreds of yards.

This closed the case for the railway companies.

The CHAIRMAN said that when the evidence was closed on all sides, and after any evidence had been taken which the Committee wished to call, he hoped that counsel, in addressing the Committee, would turn their attention to the particular points which were actually referred to the Committeee and specially the terms of the clause that should be introduced.

Mr. JAMES SWINBURNE was then examined by Mr. CRIPPS on behalf of the electric traction companies. He said that he was Managing Director of Swinburne and Co. (Limited), and had been engaged in electrical work since 1881. He had given special attention to the action of electrical tramways and railways on telephones and telegraphs. He regarded the telephone as a most sensitive electrical instrument. Though the source of the disturbance was reduced very considerably it did not reduce the disturbance in the telephone to the same proportion.

Mr. CRIPPS: What is your view of what is known?—He (the witness) looked upon the single-wire system in telephonic communication shortly as a cheap and bad system; and he attributed all the difficulties in talking to the single wire and earth or water pipe return. The telegraph was not so easy to disturb as the telephone. For telegraphs the earth return was used, and it was also used in one sense for telephones, but that was rather a technical use of the word "earth," because, as a matter of fact, nearly all the telephones used water pipes as returns, which he considered made them more sensitive to external currents. The tramways had complete returns provided by their rails, and as to insulation, they could not insulate the rails because they wanted to make contact with them from point to point. Therefore, it necessitated the use of bare conductors. If the naked conductor is in a culvert, it must be below the level of the road; there was a slot which opened into the road and they had every possible means of allowing dirt and dust to get in because the conductor must be exposed all along inside the slot in order that the collecting brushes may reach it. They thereby had to keep the uncovered conductor miles long exposed to all that in the very worst position and in an ungetatable place. Water, and especially dirty water, was a conductor of electricity, and when that got on to the insulators and made contact with the ground the naked conductor was no longer insulated.

Mr. CRIPPS: It has been suggested that the water difficulty could be got over by drainage, and that the other difficulties were not such real difficulties as you are now suggesting.

The WITNESS said it was obvious that if the drainage system were perfect, they could prevent the water filling the culvert to such an extent that it would touch the wires; but even with the best drainage they could not drain away the damp, and the damp would cause injury. Of course, those were all matters of degree; but he thought, from a practical engineering point of view, it was impossible to practically insulate those things. That had been the experience in America. In America it was found, as at Leeds, that it interfered with the telephones, and the solution there was very simple: the authorities came to the conclusion that the roads were meant for traction and not for talking through. The double-trolly system would be difficult, so far as insulation was concerned, though not so difficult as the insulation of the double system underground. From a commercial point of view, it was not a practicable system. There was not only the difficuly of insulation, but the extra complication and unsightliness, and the great difficulty of managing the connection of the double overhead current. He regarded the single-trolly system as the most workable system for traction purposes. Referring to the Buda-Pesth system, he said that was only the beginning of a tramway system. It was only a few miles in length, with but few crossings, and was no example at all of what would be done if they had to put down a complicated urban system of tramways. Nine-tenths of the difficulty came in when they had branch lines, because the crossings of the wires and conductors had to be arranged underground in such a way that the tramway car should not have any short circuits. He did not think the problem had ever been solved. As far as he knew, the only way in which it had been done was by allowing gaps where the car was going straight along; but it would be impossible to work the system in a place like London. He did not think it would be possible to make the insulation so good as that it would not disturb telephones, and, in some degree, disturb also the railway people. If there were a clause that any interference with telephonic work would render them liable to an injunction, no engineer would proceed to put up a traction system. In addition to the difficulty from leakage, there was also the difficulty of induction, and the latter he considered generally the more important cause of disturbance. In the Leeds case, he agreed with Dr. Hopkinson that induction was a greater disturbing factor than leakage. Induction would take place with the most perfect insulation.

Mr. CRIPPS: Lord Kelvin told us that by certain alterations in the trolly contacts the difficulty might be met to a certain extent. You have made experiments, have you not, on that basis?

The WITNESS said that at Leeds he had an experiment made to find out whether that was so or not. A long flexible tube was taken from the car to the overhead conductor, so as to dispense with the trolly wire altogether, and another long flexible tube was taken to the rails at the other end of the motors. They ran the motor backward and forwards, and found that there was no appreciable lessening of the disturbance of the telephones. As to the question of expense to the Telephone Company in providing a metallic circuit, he had made no estimate, but he did not think it would be very great. It would not be necessary to double all the wires on an exchange because some were disturbed; if those that were specially affected by the traction currents were provided with a metallic circuit that would deal with the difficulty. He did not consider that it would be necessary to alter the switchboards in order to have a metallic-return system. As to the railway signalling, it would not be very expensive for the signals to be protected by a metallic return; one return for each signal-box would be sufficient. Apart from the question of traction currents, he had no doubt the telephone companies would be driven to adopt the metallic-return system. The National Telephone Company's licence would soon be out; there would be other competing companies who would compete with the National Company with a lower price or better service, or both. He had had occasion to investigate the disturbances to the telephones at Bournemouth caused by the electric light operations through the use of alternate currents. He could hear the hum in the telephone, but though the disturbance was very annoying, he could talk through it.

Mr. PEMBER: What system would you propose for London?—I submit that in considering the case of London, not only the systems at present in use must be looked at, but also those which may come forward in the next few years. A great many engineers were contemplating the use of surface conductors, made alive, as it were, by the car going over them, when it could collect current from them, and directly they passed over them they would be dead pieces of iron. Such a system as that may be the only system we can use in London, but that would require to be connected with the earth.

Has any such system as you are suggesting ever been at work?—Not commercially; it has been tried.

Then if that is the fact it is hardly fair to say that our clauses have stopped electric traction being worked in London, is it?—I do not think your clauses have been the cause. I would introduce the overhead system wherever the people would stand it; it is simply a question between the alleged beauty of the streets against tramway conveniences. It must be remembered that though the telephone wires are often a long distance away from the disturbing cause, the water pipes are frequently laid down along the streets, and if the companies got their connection through the water pipes the disturbance would be communicated.

Mr. POPE: You spoke of the roads being made for traction and not for talking; what did you mean by that?—I meant that to be my summing up. All the circumstances of the case should be taken into account. I did not mean to advocate any such extreme views as that the road might not be taken up to lay down water pipes, although that might impede the traffic.

With regard to gas and water pipes I understand you to say that the ordinary practice is to connect the telephone wire with the water pipe in a house, which, of course, is connected with the main of the water company?—Yes, that is the practice; I do not know whether the water companies ask for way-leave.

With regard to your companies the case is somewhat different. I believe you gave us the advantage of your assistance in the discussion of the Electric Lighting Orders for the obtaining of clauses for the protection of the gas companies; there it was decided that whenever any electric line may be laid down crossing, or liable to touch, gas mains, pipes, or services the conductor carrying the electric current shall be effectively insulated in a manner approved by the Board of Trade, and that the undertakers should not, except with the consent of the gas companies, lay down any electric lines so as to come into contact with any mains or pipes, nor employ any mains or pipes of the gas companies as conductors for the purpose of completing the electric circuit, or for the conveyance of electric currents. Does not that apply to this case?—As a matter of fact gas does get out of the gas pipes, and there is a possibility of leakage in the case of a culvert. If there was a possibility of the electric current eating away the gas-pipes it would be only fair that the gas companies should have protection, but I did not think that would happen. It would not be likely to happen with a properly arranged system.

Mr. CRIPPS: So far as traction companies are concerned, would you get uniform currents or not?—You do not get uniform currents, you get direct currents, but it is the variation of these currents which causes the disturbance.

Do you think the danger of electrolytic action in regard to the gas mains could be provided against?—Certainly.

Whether you have a metallic return non-insulated or a ground return?—That is the same thing. The simplest way is to have the ground return as the negative conductor, and with the Gas Company's permission I should like to make them the negative pole.

By Mr. FORWOOD: He had studied the tramway system in America a good deal, but had not seen the Boston system. He believed it was entirely overhead. At one time they started a culvert system, he believed, but had given it up. Asked if there was any culvert system besides Buda-Pesth, witness mentioned Blackpool, where there was a short line along the esplanade.

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By Mr. MOLLOY: As a matter of fact any electrolysis would only prevent the pipes from rusting. An ampere would eat away about six or seven grains in an hour.

By Lord CLIFFORD OF CHUDLEIGH: Theoretically it might be possible to get over the difficulty of passing points, as at Buda Pesth, by storage; in practice the increase of weight of the accumulators to the cars would be a very serious drawback.

Mr. R. E. CROMPTON was then called. In reply to Mr. GRAHAM, he stated his firm, in connection with several other firms, had been asked by the Glasgow Corporation to carry out an undertaking on the understanding that they should take over the responsibility of complying with the protective clauses introduced into their Provisional Order, and they found themselves utterly unable to take the responsibility on their shoulders. He spent a long time in trying to find out if it were possible to devise means to so arrange their plant that they should not affect the telephone lines, and the result of his investigations was that he was reluctantly obliged to write to the Glasgow Corporation, and inform them that they could not undertake the responsibility. He found that there was no known means in the world of doing what they were asked.

That is to say, it is practically impossible to insulate electric tramways in such a way as not to interfere with telephones?—I found it was impossible so to insulate as to make it quite certain that we should not interfere with telephones. Double overhead conductors would be out of the question in this country; any attempt to make a double overhead system was a waste of time, as he did not think it would be permitted. Single overhead conductors had been greatly objected to by local authorities. His intention was to attempt to perfect a system of underground insulated conductors; he had made inventions and taken out patents, but he regretted to say he had not been able to introduce them into any complicated system of lines. There were difficulties in the way of crossings, and so on, which were apparently easy to overcome until the details were considered, but the difficulty of working with two insulated conductors was so great as to be practically impossible with our present knowledge. The double insulated conductors would involve a number of blanks, or places where one of the conductors was stopped off, and the car would be without propelling power on those parts. He had been to Buda-Pesth and examined the tramway system there. It had been constructed regardless of expense, and was a magnificent piece of work, but at the same time, they had not attempted to deal with the difficulty of blanks. When a car stopped it was shouldered over the crossing, the guard putting his shoulder to it and shifting it over.

What do you consider will be the future mode of working tramways by electricity?—I think that a slot system will probably be used. It would be necessary to have the rails insulated so far as they could be, but he did not think they could completely insulate the rails under ordinary conditions.

Is it possible to insulate in such a way as to insure not interfering with the telephone?—In my opinion it is not possible. He should think only a microscopical current would pass to the gas pipes: the question of electrolysis due to leakage for continuous currents was one which had been enormously over-estimated and exaggerated. During the number of years they had been at work in London he had taken every means in his power to ascertain if they were actually doing the damage by electrolysis that it had been contended they would do, and he had never yet traced a case, provided the precaution were taken of connecting the proper pole of the generating system with the earth. They were allowed to connect any pole to the earth under the Board of Trade's rules at present, but on account of many of their conductors being in private houses, where there was always leakage, it was much easier to arrange that the bulk of the leakages should be on one side of the system, so that they could get the negative pole of the system nearest to the earth's potential; when that was carried out there was practically no attacking of the metallic pipes whatever. He believed that all the cases which had been returned had been due to current when other poles had been at earth's potential; under such circumstances they knew that accidents took place very rapidly. As a rule, in such a case, the insulation of the electric lighting mains suffered a good deal from leakage. They only discovered this by actual practice two or three years ago, and now that they had discovered it they had no longer any further trouble. He had a great many mains in London under his control, and he was convinced that the ordinary corrosive action of certain soils in London was infinitely in excess of any such action which took place from this source.

It has been suggested that as electric lighting companies can live under these clauses, therefore tramways can, what have you to say to that?—The cases are so very different that I cannot compare them. The electric lighting companies can show that their own mains are practically tight, and the leakage through them is so infinitesimal that it need not be considered. In the case of a tramway a large portion of the conductor must be exposed to be rubbed by the collector of the tramcar, and on that portion conducting matter, such as muddy water, or, what was worse, the shoddings of the rail, particles of iron mixed with mud, or nails, might fall, connecting it with the earth. There is nothing of that kind to be taken into consideration in the electric lighting system.

Mr. PEMBER: What has your experience of traction been?—I have only constructed one tramway, at Southend. It is two miles in length, and had paid its capital twice over, I believe. The system is a return by the rails, with one conductor. The line runs from the town to the end of the pier. I am aware that there is a tramway being constructed in the Isle of Man, but there is a difference between a tramway being constructed and working. I might say that it is a very simple line in the Isle of Man.

Are not the copper wires a little to one side of the slot at Buda-Pesth?—That was the first thing that occurred to me, but I saw that it did not answer. I got permission to go to the works, and saw one of the covers off. I could see where the mud was wiped each time by the rubbing contact. The tramway worked with a leakage, and did not answer so perfectly as they were given to understand.

The Committee then adjourned.

FRIDAY, JUNE 23RD.

Mr. CROMPTON was again called to give further evidence, and, in answer to Mr. GRAHAM, stated that there was no attempt made at present to get over the difficulty of the crossings at Buda-Pesth. Double ploughs had been tried on other tramways, but the extra complication involved was so great that they did not derive the advantage from them they expected. Two conductors in a conduit were very much more difficult to insulate than one. The space between the conductors had to be greatly augmented at Buda-Pesth. Such a culvert, although possible at Buda, where there were not many underground gas and water pipes, was absolutely out of the question in our cities, like London, Manchester, or Liverpool, and therefore the talk about that system being a possible system in England was, in his opinion, entirely useless.

By Mr. MOLLOY: It was practically impossible to carry on the traction system without allowing some leakage.

Earl RUSSELL: You say that the complication in the crossings would interfere very much with using a double slot; do you think to use one overhead wire insulated, and one underground return also insulated, combined trolly and plough system would work?—I have not worked out the problem; there are possibilities in it.

If it did work, it would do away with the difficulties about crossings?—Yes, apparently.

Mr. BENNETT was the next witness. In reply to Mr. CRIPPS, he said he had received an order from the House of Lords to give evidence, without which he should not have come. He had had 24 years' electrical experience, and 13 years' experience as a telephone engineer, and was at the present time general manager and electrician to the New Telephone Company (Limited). He was the inventor of the telephone translator, an instrument which made it possible to connect metallic or circuit-trunk lines by single wires without return. He had also invented the overhead house construction adopted by the National Telephone Company in Glasgow and other Scottish towns, which system was now being introduced into London.

What would be the difference between the cost of a new telephone exchange on the metallic-circuit system and the amount generally spent by the National Telephone Company on constructing single-wire exchanges?—A metallic-circuit exchange if it is not from the beginning exclusively for metallic circuits, and without any intention of putting up single wires in the ordinary way, would not cost appreciably more than a single-wire exchange with only one. The adoption of the metallic system enables the individual wires to be grouped closely together without any interference with the efficiency of the service, so that the wires may be put into cables, and a great many may be contained in a small diameter. The open wires which have to be used in a single-wire exchange have to be strung up by supports, each wire being kept at a distance which should not be less than 8in. or 9in. apart, 12in. being the preferable distance. Therefore, the space unoccupied by the wires on the single-wire exchange is necessarily much greater than if the wires are put into a cable.

Is it possible to put the wires into a cable?—It is possible for short distances, but there are practically defects in the method which weigh very enormously against it. If single wires are put into a cable they are necessarily brought very closely together, and the induction which takes place between wire and wire is greatly augmented, so that except on very short lengths the induction is very much greater between single wires if grouped in a cable than if strung separately overhead.

Is it your view that the cable can only be used effectively if you have a metallic return system?—Most decidedly. The cables do not occupy so much room on the roofs, as the wires are in a much smaller space, and require very much smaller supports, poles, and standards than open wires to the same number would. With underground wires the only practicable system would be the metallic-circuit return.

In your view would it be necessary to have an absolute duplication of every wire?—No. I should regard such a system as practically impossible. I should abandon all idea of exactly doubling the number of open wires, but I should replace the open wires to a very large extent by cables containing metallic circuits, these cables to be put by preference underground. The cables could be erected and not brought into use until they were needed, when they could replace an equal number of circuits upon a single wire. Instead of doubling every single wire it would be possible to use a few common return wires of high conductivity which would replace the earth at the subscribers' stations and also at the telephone exchange; such a method would not be so complete a one as the entire doubling of the single wires, but for all practical purposes in an old town where the single-wire system had been installed it would suffice, and that would not be nearly so expensive. The most perfect protection for the railway signals would consist in the absolute duplication of the wires working those signals, but the disturbance might be got rid of also in two other ways—first, by a common return wire, or, to avoid accidents, two separate return wires joined together might be used for a considerable number of railway instruments.

In cross-examination by Mr. PEMBER, the witness was closely pressed as to his connection with the New Telephone Company, and he refused to give information which he had received confidentially. He was also examined as to his alleged reluctance to give evidence.

Mr. ALEXANDER SIEMENS was the next witness. He stated that the exchanges at Johannesburg and Edinburgh were metallic returns, and so were the exchanges which the Government had put up in India. The exchanges in Australia were being changed into the metallic-circuit system because the telephones as soon as they multiplied interfered with each

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other, apart from extraneous influences. This was done at great expense, but they could not have an efficient service without.

Mr. WALLACE: Should block instruments for railway purposes be insulated by metallic returns?—As a matter of fact the block signals are mostly already guarded against single-current impulses.

Does the making of metallic-circuit returns for telephones mean the doubling of all the wires?—Not necessarily, but if you want to get rid of induction as well you should double all the wires. In the Leeds case the chief difficulty to be dealt with was the difficulty from induction. He believed for telephonic purposes underground wires would take the place of overhead wires; the tendency in general was to get rid of overhead wires and put them underground.

Mr. J. H. GREATHEAD, C.E., was then examined. He said, in reply to Mr. GRAHAM, that he had for many years devoted his attention to traffic facilities in towns. He gave statistics with regard to the City and South London Railway. In consequence of complaints as to disturbances, he had a consultation in 1891 with Mr. Preece, and at his request made certain alterations. Since that time he believed there had been no disturbances of any importance. The cost of the Liverpool overhead line was £85,000 per mile.

Mr. F. JENNINGS PARSON, the next witness, stated that he was Chief Engineer of the Thomson-Houston International Electric Company, Paris. The double overhead system had been in use in Cincinnati in the United States for some time. It was satisfactory as far as it went, but it cost a great deal to install it and keep it up. In America, where there was a scattered population, they usually took a single-wire return for a group of houses. The effect of electrolytic action had been felt there, and it was sought to remove it by putting down a very much heavier return wire. In Boston, which had, perhaps, the largest tramway stations in the world, they found that the currents strayed so much as to produce more or less electrolytic action, and they were now putting down a wire of 18 diameter.

Mr. PEMBER: What other system besides the overhead would you suggest?—I would suggest brackets running along the side of the street.

Mr. S. SELLON was then called, and stated that the clauses seriously impeded the development of electric traction.

Major-General WEBBER was asked which was the better system, the overhead or the underground. He said that wherever conductors were more than seven or eight in number he should place them underground. With that number, or less, he thought they should be overhead. If overhead wires were used they were bound to have a metallic-circuit system. In the case of lines which might be put overhead, having seven or eight conductors, one strong metallic return would be sufficient, and therefore the duplication of the line, would be entirely confined to the small branch lines running to the houses of subscribers, the average length of which, compared with the others, might be taken as one sixteenth to a mile. The relative cost of a single overhead wire and of a single underground wire had been greatly exaggerated. £11 per mile was a well-recognised figure for an overhead wire, where there were existing posts. £130 per mile would provide a tube into which a considerable number of wires might be drawn. When the ground was taken up for one such tube a number of tubes might be laid, and into each of these a number of wires could be drawn. It would be found that the cost of an overhead wire was little, if anything, less than that of an underground wire.

This closed the evidence for the traction companies, and witnesses were then called on behalf of the Municipal Corporations of England and Scotland.

Mr. HESKETH (Electrical Engineer to the Corporation of Blackpool and General Manager of the Electric Tramways at Blackpool) said that with regard to the question of electrolytic action, he had had occasion to inquire into the subject. He had recently taken up all the main streets for the purpose of laying down electric lighting conduits, and had failed to discover any evidence of electrolysis. The connection was made to the water pipes, and was in operation when he went to Blackpool last August, and the effect of the precautions which they had taken was to prevent any electrolytic action. Being interested both in telephony and telegraphy, as well as electric traction, he had made frequent tests whether the working of the tramway produced material disturbance in the working of the telephones. He had never found interference from the tramways, but the interferences were due to the cross talk from telephone wire to telephone wire. He was about to modify the Blackpool tramway system to some extent by adopting a cast-iron conduit with a lid to it, so that the tram should only open the conduit at the time that it passed over it, and make contact with the conductor in the centre of the conduit. By that means he hoped to avoid trouble from the introduction of the dirt and water, which at present affected them very much. He thought it was most unnecessary that a tramway should be compelled to use insulated returns in the way described by the witnesses for the Telephone Company, and as an electrical tramway engineer he should decidedly protest against such being brought under his charge. The difficulties in the crossings and the return were great, especially in a conduit system. He attributed the inefficiency of the telephones to the earth-return system, and said that the Blackpool Corporation had been obliged to take the local exchange into their own hands and put down metallic returns. The Tramway carried over a million passengers last year, and he should deprecate anything to injure their successful working.

By Mr. POPE: The Corporation regarded the railways as of such importance that they could not but make all possible overtures to prevent interference in any reasonable manner, and they had given a clause undertaking to work the tramways so as not to interfere with the block signals. The railway companies were also to make some alterations in their own system, otherwise they would not have been able to accept the clauses.

Mr. JOHN COOPER (Town Clerk of Walsall) said that they had a system of tramways, 11 miles 5 chains in length, within the borough of Walsall, connecting Walsall with West Bromwich, Wednesbury, and Darlaston. The tramways were at first worked by steam; but owing to the annoyances from noise and smoke, they decided to adopt electricity. The results of the working had been highly satisfactory to the public the Corporation had been pleased with it, and there had been a large increase of traffic. There were 85 telephone subscribers, while over a million persons were carried on the tramways. The Corporation regarded electric traction as of greater importance to the community than the telephones they did not wish to do away with either; but if obliged to do away with one, would prefer to do away with the telephones. There had been a practical difficulty in the working of the telephones, though there had been a certain amount of roaring, but not sufficient to prevent communication. A number of the telephone wires were attached to public buildings in the town by licence of the Corporation, and the Corporation had given the Telephone Company warning that if they made any fuss about interference by the tramways, they would withdraw the licence.

Mr. YOUNG (General Manager of the Glasgow Corporation Tramways) said that the Corporation possessed 30 miles of tramways, which were constructed at a cost of £345,000, but they were at present leased to a Company, the term expiring in 1894, and the Corporation had made arrangements for working the lines themselves on the expiry of the lease. They had powers to work by electricity, and their act contained the National Telephone Company's clause. The Council had advertised for tenders for rendering the lines adaptable for electric working, and made it a condition of the contract that the contractor should be liable for any damage occurring within the meaning of the Telephone Companies' clause. The result was it was that though they had 11 offers to tender, none of the contractors would accept the responsibility of that clause. All those who tendered refused to indemnify the Corporation against the consequences which might fall on them under the telephone clause.

Alderman WARD (Mayor of Leeds) said that in that town they had 2½ miles of tramway worked by steam and horse-power in addition to the Roundhay Park line, a little over three miles in length, which was worked by electricity on the Thomson-Houston system, and let to Mr. Gray Baker. In the Corporation Bill now before Parliament they sought power to work the other 22 miles by electricity; the Bill was opposed by the Telephone Company, whose *locus* the Corporation disputed. The *locus* was allowed, and rather than have the Telephone Company's clause put on them the Corporation withdrew the clauses proposing electric working on the other tramways, as they thought they could afford to wait. But considered they ought to have power to work those lines by electricity when they came into the hands of the Corporation. Their experience of electric traction was most satisfactory; there was no portion of the lines that was so popular as that worked by electric traction. The feeling in Leeds was that there should be no clause introduced which would prevent the general adoption of electricity on the tramways.

Sir BERNHARD SAMUELSON: Do you object to the adoption of the Plymouth clause in particular, or to any clause?—The Witness said that when the matter was under consideration they were virtually asked to insert the Plymouth clause in their Bill, but they were not prepared at that time to accept any clause.

By the CHAIRMAN: He did not wish to hurt the Telephone Company in any way, as they rendered a public service. In Leeds the telephone companies were adopting the metallic return where there was any distance. If any plan were presented to the Corporation by which they could work the electric tramways without doing injury to the telephones they would be very glad to adopt it.

Mr. KEEVNEY (Mayor of Salford) said that over £90,000 had been spent upon 13 miles of tramway line in the borough, and under the Provisional Order they had power to use electricity. The lines were coupled up with the Manchester tramways, so that they formed one continuous system. This year they introduced a Provisional Order for the purpose of doubling a little bit, about 100 yards, of the tramways, but the National Telephone Company opposed them most unjustly, asking that their clause should apply not only to the piece proposed to be doubled but over the whole line. That he considered unreasonable, as they had previously obtained powers for electricity over the whole line. In consequence of that opposition they withdrew the Bill for this Session, but he added, "we shall have a go at it again." They had a right to use their own power, and did not want any one to interfere with them within their own boundary. Let the telephone companies follow their own pursuits but they must not come and block us, that is certain.

Mr. JAMES WILSON SUTTON (a Member of the Manchester City Council) said that as in future the telephones might have to be placed under the streets, he considered that it would be better public policy that they should be in the hands of the municipalities or that there should be a competitive State system. In Manchester they did not permit interference with the streets, either by gas or water companies, electric lighting companies, hydraulic companies, or anyone else; the Corporation did everything. The Manchester Corporation owned about 30 miles of tramways which were linked up with those of Salford and Oldham. They wanted to secure in the future the very best mode of traction which science could suggest, and it appeared to him that if they were debarred from using electric traction to serve the interests of a private company it would be a very serious matter. Comparatively few persons used the telephones, but millions of persons used the tramways, and if the two interests were in conflict, the Manchester people thought the public interest should be considered before the private interest. Any system of telephony which could be interfered with by electric traction must be an imperfect system.

By the CHAIRMAN: They did not want to do any harm to the telephone system at Manchester, they wanted to develop it, and deplored the fact that it was so imperfect. The Manchester Corporation would prefer to see the wires laid underground, but would give the right to break up the streets to no individual company.

The Committee then adjourned.

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MONDAY, JUNE 25TH.

At the commencement of the proceedings the agents for the Corporations of Nottingham and Liverpool informed the Committee that though those bodies agreed with a great deal of the evidence which had been given by the Municipal Corporations of England and Scotland, they desired it not to be taken as agreeing to everything that had been said on their behalf.

Major CARDEW (Electrical Adviser to the Board of Trade) was called by the Committee as an independent witness, and stated that it had been his duty to make examination in various cases in which accidents had occurred. Since 1887 he had given a great deal of study to the question of electricity. Sir Courtenay Boyle had requested him to correct his evidence with regard to the accidents at Preston, which he had attributed to electrolytic action. That, at any rate in the witness's opinion, was not the case. He attributed those accidents to heat caused by the passage of the electric current between the iron culvert in which the electric light mains were contained and the gas service pipes which were injured. By the courtesy of the Preston Gas Company he was able to produce specimens of those service pipes which were cut out immediately after the accident. That which was the result of the accident in Wheatley-square on January 27th last had a hole eaten out of it where it was in contact with the culvert, and on January 25th the lead service pipe in Wheatley-square was melted.

The CHAIRMAN: What do you attribute that to?

The WITNESS said that he attributed it to an electric arc set up in the first place by imperfect contact between the culvert and gas-service pipe, and as the gas-service pipe melted away, the arc was established which caused the fusion, and which was due to the imperfect state of the works of the Electric Light Company. One side of the circuit had a temporary connection with earth, accidentally formed, and the other side of the circuit was accidentally brought into connection with the iron circuit enclosing the main. On February 24th a service pipe to a stationer's shop in Fishergate had three inches of it melted where it came in contact with the Electric Light Company's culvert. Those accidents were not due to electrolytic action, but to something much quicker, viz., heat produced by a current of electricity through them. The dry and sandy nature of the soil in Preston, in his opinion, had something to do with those accidents.

Mr. FORWOOD: Then the heat which was produced was due to faulty insulation of the mains inside the culvert?—That is true.

Earl RUSSELL: I understand that those are due to accident; if so, it would be impossible to prevent those by protective clauses.

The WITNESS said he did not think it was impossible to prevent accidents happening, although he did think the likelihood of serious accidents happening might be very greatly diminished by precautions which might be taken as a result of attention to regulations. He did not wish to bring anything in the way of accusation against the Electric Light Company, as they were but starting, but he thought under the circumstances, and the engineers of the Company would agree with him, sufficient care had not been taken before the accident. A long line of culvert, containing bare conductors, being allowed to come so near the bare unproducted gas pipes was an error of judgment, and was probably due to the hurried way in which the installation was carried out.

By Mr. MOLLOY: The electric conductors were strips of copper in the iron culvert, which was roughly half a cylinder with a flat top, and the electric light strips being held on insulators inside were separated from the culvert by 2in. or 3in. everywhere. But the connection was not made through any failure of contact between the strips and culvert, but was owing to defective arrangements in switching in some lamps for public lighting, and by that means the electric light conductor was brought into connection with the lamp post and the culvert, and thereby escaped to the gas pipe, which had previously been used for supplying the lamp.

By Sir BERNHARD SAMUELSON: Such accidents were certainly preventible. As far as his experience went he did not think it was usual to have lead gaspipes underground, but they were usually iron

By the CHAIRMAN: His attention had been drawn to several other cases of damage to water and gaspipes, and by tests which he had carried out he was enabled to prove that damage was caused by electrolytic action. He produced one of the pipes which was very much corroded throughout, but thought it better not to mention the name of the town in which the damage occurred. The difference of potential which he found on testing between the electric culvert, which was of the same character as the one in Preston, was 6 volts, which was quite enough to account for considerable electrolytic action. The pipe was full of water at the time, and the same current which was flowing through it and causing corrosion on the positive side must also have been causing corrosion on the negative side. On the subject of electrolytic action, he would like to mention the question of metallic connection between the negative terminal of the dynamo and the water mains in the case of dynamos. In the case of the Leeds Tramway and one or two other tramways, that connection was made by his suggestion, but it had never been the subject of any regulation, for one reason, that the Board of Trade was not empowered to make regulations on any water company. But considering the conditions that the current was being returned by uninsulated rails, and that there were water and gaspipes in the immediate neighbourhood, he considered it most essential that the Tramway Company should take all reasonable precaution to prevent damage to the pipes, and he suggested that a good way to do so would be to connect the negative terminal of their dynamo to the water main, the result of that being to raise the whole of the electric circuit in what is called potential positive to the water mains and the earth. If that were the case, any leakage crossing between the electric system, including the uninsulated rails, and the water pipes would tend to corrode the rails and to preserve the water pipe. That connection was made about a year and a-half ago, but he had never felt absolutely satisfied and certain in his own mind; he thought very few people were quite certain as regards what might happen with new developments of electricity. When visiting Leeds a year ago he discovered that the potential of the rails, as he had anticipated, was everywhere positive to the water pipes, and amounted to two volts at the extreme end. He could not find any sign of injury to them, although the road was opened in many places. As a year had since elapsed, he proposed to go down to Leeds again to see how that arrangement worked.

By Major DARWIN: In the case in which electrolysis had happened, it might have occurred inside as well as outside the pipe, but they would not be able to get at the inside. The soil in which the pipes were laid was wet and also salt. He handed into the Committee an interesting article* on the subject from a French paper, *L'Industrie Electrique*.

By Mr. MOLLOY: In the last case which he mentioned no doubt there was chloride of lead there, but he thought the rapidity with which the action took place quite negatived the idea that it was due to any impurity in the soil, and also the fact that when he tested there was a steady difference of potential of six volts. The pipe had had to be changed at intervals of about six weeks for several months in succession, and during that time there had been an earth fault on the mains of the Company which they did not know of. While that earth fault was on there were continual failures of the gas pipe. The damage was confined to one section of the pipe, and the electrolytic action occurred only at the point where there was an accidental contact with the earth. That was certainly preventable, and the imperfect means of localising and testing was the cause of that fault remaining so long. He had no doubt any such fault would not be left for any length of time now, since attention had been drawn to the matter. In the case of a tramway working with uninsulated returns precaution should be taken that the leakage did not hurt other people. They could not prevent its hurting something, but by the means he had suggested it might be confined to their own rails.

By Mr. FORWOOD: Having regard to his experience, he should say that the Leeds system might with proper precautions and proper watchfulness and testing (which was a most important point) be carried on without any damage to gas and water mains. Two volts was about the amount of electromotive force that was necessary to produce electrolytic action. The main object of the clause in the Electric Lighting Orders forbidding earth connections with houses was the protection of the consumers into whose houses electricity was brought. The Board of Trade had always been advised that an earth current should not under ordinary conditions, and with the conductors which were generally used, be taken inside houses, but with the approval of the Board of Trade and with the sanction of the Postmaster-General, to whom it might be an annoyance, they were permitted, under certain safe conditions, to use an earth connection for other purposes.

By the CHAIRMAN: Since he had been informed of Mr. Preece's experiments on the City and South London Railway with regard to leakage, which was a matter which had not been brought to his notice till the week before last, he had suggested to the engineer of the Company that he should carry out certain tests with the view of gaining information as to where his leakage occurred, what it amounted to, and how it might be prevented. The only time which was available for testing under the working conditions of that line was on Sunday morning, when the engineer took those tests in as nearly as possible the way in which he had asked him to do, with a steady current through the system of 140 amperes, which, as regards fall of potential, would be equal to a 280 current equally distributed. The result was to show a maximum difference of potential between their system and the gas and water pipes (which was one thing he was very anxious about) of 2½ volts, except at one station where there was a difference of potential of about 4 volts between the gas pipes and the negative terminal of their system. Considering those tests when they were brought to him on the Monday, he suggested that probably they would find a metallic connection at that point between their rails and the gas pipes, and the next day he was informed that that connection had been found, and he thought that was in a great measure the cause of the ringing of the bell which Mr. Preece had mentioned. He entirely agreed with Lord Kelvin in certain answers which he gave as to improvements which might be made in railways and tramways for preventing the injurious action such as he had described, the gist of which was that in his opinion certainly great improvements could be made by which, probably even under existing systems of working, interference could be avoided. It was impossible to absolutely avoid any interference between any two electric circuits on this earth, but practical interference was a very different thing. They had first of all to utilise the whole conductivity of their return rails; the more they increased the conductivity of the rails the more they diminished the loss of potential in the rails and the leakage of current outside. In the City and South London the sleepers were not creosoted, and conducted electricity more than they need. In the case of tramways, also, what they had to aim at was to take advantage of the whole conductivity and increase it by additional conductors to the return circuit, and adopt, as far as practicable, the same system which was used in the case of electric supply to maintain a uniform pressure throughout a large district. In the case of electric supply by the Board of Trade regulations, they were only allowed a variation from the proper pressure of 3 per cent. in their mains. If the tramway companies were to maintain a potential within 3 per cent. it would not interfere with anybody, but, of course, the conditions were not identical. A constant unvarying current would not affect telephones in the least, however much was escaping to earth, but in the case of tramways it was always varying. Sparking of the contact, sparking of the brushes, vibration in the motor, and in the way in which the motor was wound, was sufficient to cause the sudden variation. No doubt improvements such as he had indicated would be carried out to do away with that annoyance, and would not cause any very great expense, but he attached the greatest importance to systematic testing.

* Abstracted in *The Electrician*, Vol. XXIX., p. 675.

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By Mr. BRUNNER: Up to the present, as was very natural, the efforts of the electric tramway and railway authorities had been directed to those sides of the question which dealt with getting the most return for their money, but he did not think there would be any unwillingness on their part to make the tests which he had suggested now that they realised the importance of them, and they would no doubt put the results on record, so that the Board of Trade could have access to them. He thought they would do that without any compulsion, though it might be advisable that they should be bound to produce the record of the tests when called upon.

By Earl RUSSELL: At present the companies had been so much occupied in getting powers to run at all, and had not had time to pay attention to the niceties of adjusting the brushes, and so on. They had been endeavouring to get the system into practical working order, which was the natural thing to do, and as regards interference they were probably leaving that until some amount of compulsion was put upon them.

Earl RUSSELL: You think they will do it when they have time?

The WITNESS: If they have a sufficient motive. He could not say if the double insulation system for tramways was practicable, as he had not sufficiently studied the question, but it certainly was a more complicated system, especially in the case of feeders. If they had a 10-mile line of tramway they must not attempt to bring the return on one line of rails along the whole length, but insulated feeders might be adopted.

By Mr. MOLLOY: Electrolytic action was a thing that could be avoided with ordinary care, and in the future there was no fear of any large extension of that danger to gas and water pipes. He did not see the necessity for any regulations to secure that object, but assuming suitable regulations were drawn up there was no danger to be apprehended.

By Lord CLIFFORD: There was just sufficient leakage from the Leeds Tramways to set up electrolytic action, and no doubt some such action was going on, but it was in the direction of the current and was not in such a position as to damage gas or water pipes, but would rather damage the rails.

By Major DARWIN: The effect of inductive action from tramways upon telephones might be experienced for some hundreds of yards, but as regards leakage there were so many things to be considered that it would be difficult to say where the effect might be stopped or where it might be found. It depended on what pipes were in the ground, the nature of the ground, and also on the volts lost in the ground.

Sir FREDERICK BRAMWELL was then examined by Mr. POPE on behalf of the Gas and Water Companies. He said that he had given attention to the subject of electrolytic action. In the case of electric lighting it could only be produced by accident, but in the case of tramways, like the Leeds tramway, with uninsulated returns, it was a constant and real danger. Major Cardew's proposition to connect the negative pole of the dynamo to the water pipes, it seemed to him, did not take account of the fact that they must have continuous water pipes. The pipes might stop, and they would have the gas pipes left unprotected. The water pipes, too, had joints which were absolutely impermeable by electricity. It must also be borne in mind that most water pipes were coated with Angus Smith's composition, a black varnish, which was not a good conductor of electricity. This was not a new subject to him, for it came before him in the case of Lane Fox against the Kensington Electric Lighting Company. In that case, the suggestion was made of using the water pipes as a return (they being included in the term "earth"), and the question of electrolytic action was raised, the conclusion at which he arrived being that it was dangerous and ought not to be allowed. He would like much more experience of Major Cardew's plan as to its effect on gas and water pipes before he could assent to the proposition that it would remove all cause of anxiety. In his judgment the only method of securing safety against electrolytic action was the proper insulation of both the outgoing and incoming conductor from the earth so that there should be no leakage whatever, except in time of accident, and in that case it would be very different from the harm done by interference with the telephones. The waste of a pipe by electrolytic action was due to the amount of the current and the time during which it acted. Supposing there were a failure from some accident; if perfect insulation and electrolytic action were set up it might go on, perhaps, for one day in the year, or for a week in the year, and the harm done would be in proportion to the time it went on. In the case of telephones the annoyance was immediate. In the case of the gas company it was dependent on the time and quantity, therefore any system which prevented heat and which had any imperfection would still be defective. He did not regard a provision for the prevention of such action as being prohibitory to electric traction. He could not imagine that legislation would ever allow the streets of London and the suburbs to be worked by means of overhead lines. If they did not, there was no other method except working by accumulators, which was perfectly feasible and innocuous, or by conveying the electricity in tubes underground. If the latter plan were adopted there was no difficulty in having both the incoming and outgoing mains in the tubes.

By Mr. WORSLEY TAYLOR: When he spoke of the Leeds system as being a real danger, in fact he had found none, but one of the things to be considered was that the harm was covered up. It might go on and nobody know anything about it until the rupture took place.

By Lord KELVIN: In the case of electrolytic action upon water pipes there was not much risk to life, but in the case of gas pipes being ruptured when the road was covered over with concrete, they knew nothing about it until the gas came into the area of the house and into the kitchen, the kitchen fire got hold of it, and the result was a serious explosion.

Dr. J. HOPKINSON was recalled, and stated that he had long held that there was a probability of oxidisation to the pipes from the currents meeting and passing through them, but it was only comparatively recently that he had realised how serious the disturbance might be. His view was that the only thing which could be done to protect against the oxidisation was to insulate the whole system of electrical conductors as used for tramways. To show that the danger to gas pipes was of a serious character, he produced a gas meter in which two holes had been eaten by the action of electricity. Paint would act slightly as a non-conductor, but it was easily scratched off. There had been many cases of very serious explosions occurring in the streets from undetected leaks from gas pipes. The worst thing that could happen would be that there should be actual metallic connection between the rail and the gas pipes. They might have the current leaving the gas pipe at one point and returning to it at another, and so causing oxidisation. Gas pipes were more or less moist. Gas companies, of course, did not trouble themselves much as to whether the soil in which they laid their pipes was moist or dry. Between the two flanges of the joint of a water pipe was a piece of millboard, which if dry was an insulator, but if wet it acted electrolytically. With an ordinary spigot joint he believed this would not occur. He thought culverts with slots in them were not found to interfere with traffic in any way.

By Mr. BALFOUR BROWNE: The gas meter which he had produced was a case of an accident occurring in an insulated system, but it had been allowed to exist for many months, when it should have been seen to at once.

By Earl RUSSELL: He did not agree with Sir Frederick Bramwell that the black varnish on the outside of the pipes would prevent them from conducting to the soil; the varnish was spread over a large area, and was very thin. He was not aware of cases occurring where flange pipes had been injured.

Prof. DEWAR was the next witness. He stated that his attention had been directed, purely from the chemical side, for some years past to the question of electrolytic action upon gas and water pipes. He was well aware of Papers dealing with the damage which had occurred in America, and especially called attention to the Paper on "The Electrolysis of Water Pipes," which appeared in *The Electrician* a fortnight ago.*

Mr. POPE: So that it is a danger present to the mind of those interested in electrical service, not only here, but on the other side of the water also?—That is quite clear.

What do you say is the condition which can alone remove the danger?—The only condition is the one foreshadowed by Sir Frederick Bramwell and Dr. Hopkinson; that is, of course, the removal of the possibility of electrolytic action, on the one hand, that something might be done by connecting with the negative pole the water mains. I ought to say that the suggestion appears also in this paper, and it was dismissed in America as impracticable unless it was connected with the gas mains as well: so they take a different view. I take the view that the proper course would be undoubtedly to have much more insulation.

Would you, therefore, rely, as a practical measure, on this connection of the negative pole with the water mains?—No, I would not. My serious difficulty is, of course, the chemical question of the corrosion of iron pipes in the sub-soil. In our time, many chemists have devoted their attention to that both at home and abroad; but the problem is an exceedingly complex one. It varies very much with the character of the iron, and very small pieces in chemical composition affect enormously the rapidity of the attack. Then in the sub-soils, where there is a large amount of drainage, the sub-soil is stored with carbonic acid and ammonia, along with nitrates, and these are conditions under which the pipes are oxidised. The principle of keeping a large metallic system practically connected with the negative pole would mean to transform the metal into a condition that would not be attackable, owing to an infinitesimal layer of hydrogen: but, unfortunately, the condition of the chemical fluid surrounding the pipes in the soil is exceedingly favourable to the removal of this minute layer of hydrogen.

So that the corrosive action takes place, although a remedy may temporarily be made available?—That is what I say; there is no guarantee that it will be uniform over that large metallic area of the pipes. I know of no real remedy but absolute insulation.

Mr. BALFOUR BROWNE: With regard to the Paper in *The Electrician*, having reference to electrolysis in America, how many tramways are run by electricity in the United States?—That I could not say. This was a special case dealing with Cambridge (Massachusetts).

Have you ever heard of any but that one case?—I have seen no other records as yet.

By Mr. BRUNNER: It was exceedingly difficult to localise leakage in a large system. Variations in the insulation could, no doubt, be recorded, but where to find the defect was another matter. His difficulty as a chemist was that, while you might save the equivalent electrolytic attack on the iron for so many points, that did not prevent the natural and corrosive attack being greatly accelerated by the indirect effect of the passage of the current. It was not only the equivalent to the current doing damage to the pipe by oxidation, but the question was, What would be the effect of this upon the ordinary rapidity of corrosion which took place in the sub-soil? He thought that in the majority of cases it would be accelerated. Many things had been done to protect water pipes, and nothing had been so successful as Dr. Angus Smith's coating of tar or pitch; but even this, not having the same coefficient of expansion as iron, cracked and came off.

Mr. FOULGER (Chief Engineer of the Gas Light and Coke Company) was the next witness. He stated that he had great difficulty in coping with escapes under the London streets that were concreted. The escape of gas percolated through the earth from the place of leakage a considerable distance. There was another danger which had recently been illustrated in Oxford-street; the concrete on which the pavement was laid formed almost a perfect arch, and the loose friable earth with which London roads were constructed was continually sinking, the consequence being that large cavities were left between the concrete and the earth. He

* June 16th, p. 172.

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viewed the danger to the gas pipes with serious apprehension. The total loss of gas in transit amounted to 4 per cent., but less than 1 per cent. was due to leakage, the greater part being due to difference in the temperature at which the gas was registered at the works and the private houses. Cast-iron pipes put in a suitable soil were, he thought, practically indestructible; he had seen pipes that had been in the ground for upwards of 50 years which were as sound as a bell.

Mr. EPSTEIN (Managing Director of the firm of Epstein and Co.) was then examined and gave particulars of the Birmingham Central Tramways and calculations as to the cost of traction by accumulators.

Mr. W. H. CHRISTIE (Astronomer Royal) then gave evidence as to some disturbances in the instruments at Greenwich, owing to the working of the City and South London Railway. It had struck him as curious that the disturbances in the two circuits should have been the same approximately, and the only explanation he could suggest for their difference was that one of the earth-plates being near the river, the electricity was carried down by water, which was a better conductor. They had noticed another disturbance confined to the night hours, the only explanation they could make for which was that it might be due to the effect of some electric lighting near the river.

The CHAIRMAN: Are these observations of so great importance that we should put costly restrictions upon the Railway Company in order to protect you against them?—I think it is hardly of sufficient importance, from the scientific point of view.

This concluded the evidence, which will be laid before the Committee, and the Committee then adjourned.

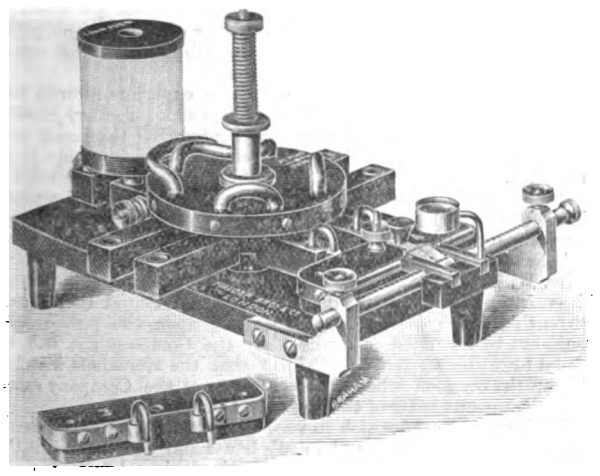
On Tuesday the speeches of counsel were taken, Mr. Pember, Q.C., addressing the Committee on behalf of the Telephone Companies; Mr. Moulton, Q.C., for the Railway Companies; Mr. Balfour Browne, Q.C., for the Municipal Corporations; Mr. Cripps, Q.C., for the traction interests; and Mr. Pope, Q.C., for the Gas and Water Companies. In regard to the application of Mr. Wallace, to be heard on behalf of the Electric Lighting Companies, the Committee decided that if, after discussion, they considered it advisable, they would give Mr. Wallace an opportunity of being heard.

City and South London Railway Bill.

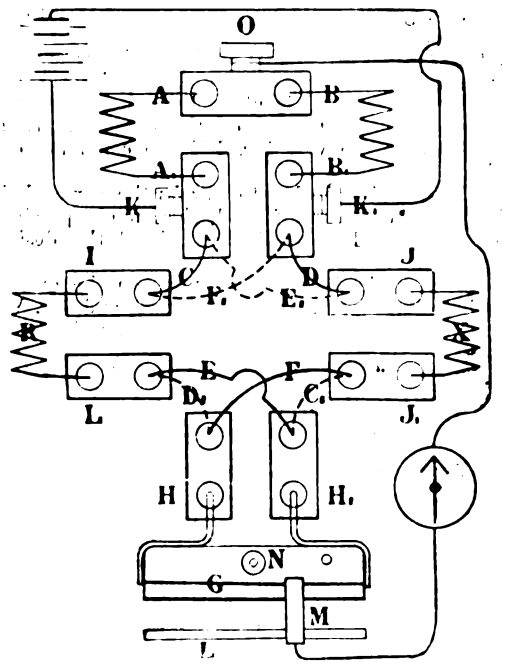
The Bill of the City and South London Railway Company to extend the time for the completion of the Subway, or Underground Railway, authorised by the Companies Act, 1890, came on Wednesday before Lord Wantage's Committee of the House of Lords; and the opposition of the Metropolitan District Railway Company and the London County Council being withdrawn, the Bill was referred to Lord Morley's Committee on Unopposed Bills.

PHYSICAL SOCIETY.

At a meeting of this Society on June 23, 1893 (Prof. A. W. Rücker, M.A., F.R.S., President, in the chair), Mr. F. H. NALDER exhibited a bridge and commutator for comparing resistances, by Prof. Carey Foster's method, the chief features of which are simplicity, compactness, long range, and great accuracy.



The instrument has been designed for commutating the resistances to be compared with respect to the ratio resistance coils and a series of bridge wires. It consists of copper bars mounted on an ebonite base, and furnished with mercury cups for making the necessary contacts. At A A_1 and B B_1 are the cups for the ratio coils which are wound upon one bobbin and usually of the value 1ω, 10ω, 100ω, and 1,000ω on each side. At I I_1 and J J_1 are placed the resistances whose difference is to be measured, and at G is the bridge wire mounted on a detachable frame, with the key M which runs on the divided rod L for making contact. C D E F show the commutator connections in the first position, and after commutation in the position C_1, D_1, E_1, F_1, as indicated by the dotted lines. In order to commutate the coils R and X, the ebonite plate upon which the connections C D E F are mounted is drawn up against the spring which presses the contacts into their respective cups, until the guide pin is lifted out of its recess, the plate can then be turned through 180deg. till the contacts are in the position shown by the dotted lines marked C_1, D_1, E_1, F_1; the galvanometer is then brought to zero by moving the contact key M into another position on its wire. The battery connections are shown at K K, and those of the galvanometer at M O.



In order to obtain a wide range of measurement instead of using a long wire, a number of short bridge wires are provided, usually about 10, though, if necessary, this number need not be considered the limit. The plate upon which each wire is mounted is detachable, as already stated, and in addition to the milled head H two steady pins are fixed in the base of the commutator, so that it or any of the series can always be replaced accurately in position with respect to the scale and key. A considerable variation of resistance of the short bridge wires shown will not vitiate the accuracy of the measurement.

Mr. W. R. PIDGEON and Mr. J. WIMSHURST each read a Paper on

"An Influence Machine,"

and exhibited their machines in action. In designing his machine, Mr. Pidgeon has endeavoured (1st) to make the capacity of each sector large when being charged, and small when being discharged; (2nd) to prevent leakage from sector to sector as they enter or leave the different fields of induction; and (3rd) to increase the capacity of the machine by making the sectors large and numerous. The first object is attained by arranging fixed inductors of opposite sign to the sectors near the charging points, and of the same sign near the places of discharges. Objects 2 and 3 are secured by embedding the sectors in wax, run in channels in the ebonite discs which form the plates of the machine, and carrying wires from each sector through the ebonite, each wire terminating in a knob. In this way the sectors can be placed much nearer together than otherwise without sparking back. By setting the sectors skew with the radius, they are caused to enter the electric fields more gradually, consequently the potential difference between adjacent sectors is kept comparatively small. Experiment showed that the use of the stationary inductors at the charging points increased the output threefold, and as compared with an ordinary Wimshurst, the output for a given area of plate passing the conductors was as 5·6 : 1. The recovery of a machine after a spark had occurred was particularly rapid.

Mr. Wimshurst's new machine consists of two glass discs, 3ft. 5in. diameter, mounted about ¾in. apart on the same spindle. Both plates turn in the same direction. Between the discs are fixed four vertical glass slips over 4ft. long, two on each side, and each covering about three-eighths of a disc. Each slip carries a tinfoil inductor, which has a brush, touching lightly on the inside of the adjacent disc, on its leading edge. Collecting and neutralising brushes touch the outsides of the discs, and the few metallic sectors attached thereto. An account of some experiments made to determine the efficiency of the machine was given. The author also showed that when all the circuits of the machine were broken, it still continued to excite itself freely, and sparked from the discs to the hands when brought near.

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In a written communication, Prof. O. LODGE said his assistant, Mr. E. E. Robinson, constructed a machine on lines similar to Mr. Pidgeon's a few months ago, and had now a large one nearly completed. Mr. Robinson's fixed inductors are carried on a third plate, fixed between the two movable ones. The sectors are quite small, and neither they nor the inductors are imbedded. On close circuit, the machine gives a large current, $\frac{1}{10000}$th of an ampere, and on open circuit exceedingly high potentials. In Dr. Lodge's opinion, Mr. Pidgeon attaches too much importance to his sectors and their shape.

Mr. J. GRAY wrote to say that stationary inductors, enclosed in insulating material, would probably give trouble at high voltages, because of the surface of the insulator becoming charged with electricity of opposite signs to that on the inductor. He suggested that this might explain why Mr. Pidgeon could not obtain very long sparks.

Prof. E. V. BOYS inquired as to how far the wax made insulating union with the ebonite, for if good, glass might possibly be used instead of ebonite. He greatly appreciated the design of Mr. Pidgeon's machine.

After some remarks by the PRESIDENT on the great advances which had been made, Mr. PIDGEON replied, and Mr. WIMSHURST tried some further experiments with a small experimental machine.

A Paper on

"A New Volumeometer,"

by Mr. J. E. MYERS, B.Sc., describing the developed form of Prof. Stroud's instrument, was, in the absence of the author, taken as read.

Mr. R. W. PAUL exhibited a compact form of sulphuric acid voltameter of small resistance. The voltameter is a modification of a pattern designed at the Central Institution, in which the rate of decomposition is determined from the time required to fill a bulb made in the stem of a thistle funnel. He also showed a handy form of Daniell cell devised by Prof. Barrett. When not in use

the porous pot containing the zinc is removed from the copper sulphate solution, and placed in a vessel containing zinc sulphate, or sulphuric acid.

A Paper on

"Long-Distance Telephony,"

by Prof. J. PERRY, F.R.S., assisted by H. A. BEESTON, was read by Prof. PERRY. The case of a line of infinite length, having resistance capacity, self-induction, and leakage, is taken up, and the state of a signal as it gets further and further away from the origin, is considered. Taking the shrillest and gravest notes of the human voice to have frequencies of about 950 and 95 respectively, the distance from the origin at which the ratio of the amplitudes of these high and low-frequency currents is lessened by $1/m$th of itself, has been determined when $m=4$ for different values of leakage and self-induction; and under similar conditions the distances at which the relative phase of the two currents become altered by $1/n$th of the periodic time of the most rapid one, have been worked out for $n=6$. The results are given in the form of tables, from which it appears that if there was no self-induction, increasing the leakage increases the distance to which we can telephone, whilst if there were no leakage increasing the self-induction increases the distance. When self-induction and leakage are not too great, increasing either increases the distance, and for particular values the distances become very large. At the end of the Paper, tables of general application are given, from which the limiting distances for any time can be readily found by multiplying the numbers by simple function of the contents of the line.

Mr. BLAKESLEY said that some ten years ago he discussed the subject where capacity and resistance were alone considered, and now pointed out that when self-induction and leakage were introduced the equations were still of the same form. He also suggested how terminal conditions on lines of finite lengths might be easily taken into consideration.

Prof. PERRY, in reply, said the introduction of self-induction and leakage rendered the calculations much more laborious, and that the terminal conditions were much more complicated than Mr. Blakesley supposed.

LEGAL INTELLIGENCE.

Cook v. St. James' and Pall-mall Electric Light Company (Limited.)

This action came before Mr. Justic North in the Chancery Division on Tuesday. It was brought by the trustees of the Windham Club (in St. James's-square), on behalf of the club, complaining of a nuisance caused by noise and vibration proceeding from the works of the defendant Company, which are situated in Mason's-yard, about 45ft. from the club. The plaintiffs claimed an injunction to put a stop to the alleged nuisance.

Sir H. Davey, Q.C., and Mr. T. L. Wilkinson were for the plaintiffs; Mr. Cozens-Hardy, Q.C., Mr. Moulton, Q.C., and Lord Robert Cecil were for the defendants.

Sir H. DAVEY opened the plaintiff's case, and read some correspondence, but, before any witnesses were called, an arrangement was come to between the parties, by which, by consent, and without prejudice to any question, the defendants undertake that if in the opinion of an engineer, to be named by the Board of Trade or agreed upon between the parties, the working of the machinery in Mason's-yard does now or at any time hereafter shall cause any annoyance by vibration or noise to the Windham Club, they will forthwith make all such reasonable alterations or additions as the engineer shall direct for the purpose of remedying the same. No order was made by the Court, except that the defendants pay the costs of the action. Liberty to apply.

Dart v. Electricity Supply Corporation.

This action, which engaged the attention of Mr. Justice Cave and a special jury on Monday, Tuesday, and Wednesday, was a claim for damages to premises and for injury to health on the part of the plaintiff, Mr. Wm. Dart, of Southampton-street, Strand, caused by the working of the machinery at the central station of the defendant Company, in Maiden-lane.

Mr. Willis, Q.C., and Mr. Ellis appeared for the plaintiff, and Mr. Fletcher Moulton, Q.C., and Mr. Turrell for the defendants.

Mr. WILLIS stated, in his opening speech, that in the year 1888 Messrs. Gatti started an electric installation in Maiden-lane, but no annoyance was caused by it. In 1891 the works were taken over by the defendant Company, and fresh machinery was put in. Vibration was set up in the plaintiff's premises to such an extent that his assistants and his tenants complained greatly, and his own health was shattered, and he was unable to attend to his business properly. Some of his tenants had left after complaining of the vibration, and he had been unable to let his rooms since.

Mr. DART said he first noticed the disturbance in the Autumn of 1891; it continued until April in the following year, was much modified in the summer months, and was intensified throughout the winter. It was impossible for anyone to sit in the rooms without noticing the vibrations, and being disagreeably affected by them. His assistant had frequently been unable to sleep at night, and his own health had suffered. One of the firms of Messrs. Gatti had visited the house, but did not admit that there was any great amount of vibration, but a Mr. Clarke, representing the defendant Company, at a subsequent time said there was certainly some vibration in the upper part of the house. He had never experienced any discomfort from the traffic in the street, nor from the other machinery in the neighbourhood.

Mr. EDWARD SEGUNDO gave evidence of experiments with mercury to test the extent and character of the vibrations, which coincided with those he observed at the defendant's works.

Mr. P. P. KIPPING gave the results of experiments with microphone and telephone receivers, showing vibrations of a pulsatory character.

Mr. TERRELL, for the defence, contended that the house was old and dilapidated, and easily shaken by persons walking about in it, by the traffic in the streets and by the printing machinery in the neighbourhood.

Dr. JOHN HOPKINSON, F.R.S., gave particulars of several visits to the plantiff's shop, and of failing to detect any vibration attributable to the Company's works; he did, however, find that the windows rattled, and the walls shook when there was a passage of traffic in the street.

Mr. W. H. PATCHELL (Electrical Engineer to the Company) produced his registers of the output at the works, and stated that the amount of current produced was entirely dependent upon the public demand, and could not be regulated or modified by the Company; it had been suggested by witnesses for the plaintiff that the vibrations were less noticeable on the occasion when representatives of the Company examined the premises because some of the power had been shut off.

The jury expressed a wish to view the premises, and arrangements were made for them to visit the plaintiff's house and the defendant Company's works on Wednesday evening. His lordship, therefore, deferred his summing up until Thursday morning.

The jury after their visit returned a verdict for the defendants. His Lordship certified for a special jury, but demurred to an application for a stay of execution. This, however, was withdrawn upon the assurance of defendants' counsel that every facility would be afforded plaintiff whilst considering the question of carrying the proceedings further.

A Long Telephone Line.—It is reported to be the intention of the Automatic Telephone Company of Canada to establish telephonic communication between Halifax and Vancouver, by means of an overhead line crossing America from east to west. The distance is about 3,800 miles.

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CORRESPONDENCE.

TESTS OF STEAM DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With special reference to some excellent results recently obtained from a large Willans-Holmes combination steam dynamo, we beg to enclose a sheet of tests of a Willans-Crompton combination steam dynamo tested this week, which although only half the size of Messrs. Holmes's combination, shows results practically as good. We only ask you to publish these figures as an additional proof that the manufacture of continuous-current dynamos is, at all events in England, now so well understood that combined efficiencies exceeding 86 per cent., corresponding to commercial efficiencies of 95 per cent. in the dynamo are the rule and not the exception.—Yours, &c,

CROMPTON & CO., LIMITED.

Mansion House-buildings, London, E.C.,
June 23, 1893.

G.G. Engine, No. 1,435, for Hove. Messrs. Crompton and Co's. Dynamo. No. 2,800. June 20, 1893.

Steam chest.	Revolutions.	Amperes.		Volts.	Time.
		Main.	Shunt.		
125	430	248	4·3	242	1 p.m.
123	431	245	4·4	240	2 ,,
123	434	248	4·3	240	3 ,,
123	441	248	4·2	240	4 ,,
123	445	250	4·1	240	5 ,,
120	445	250	4·0	240	6 ,,
120	446	248	4·0	240	7 ,,

Temperatures.—Armatures: Engine End 57°C.=135°F., Commutator, End 46°C.=115°F. Magnets, 37°C=99°F., Air 27°C.=81°F. I.H.P., 92·45: Efficiency, 86·5 per cent.; E.H.P., 79·98.

MUTUAL ATTRACTION OF VACUUM TUBES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to your editorial note at the conclusion of my letter in your last issue, I beg to say—(1) The attractive force between the tubes ceases at once on breaking the current; (2) the calculation can easily be made as to the magnitude of the force. By the roughest of tests ½oz. was about the value. During the autumn I hope to publish some more accurate details, together with some other phenomena which are interesting.—Yours, &c., DAVID SALOMONS.

June 24, 1893.

THE PRICE OF ELECTRIC SUPPLY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Permit me to reply to your strictures on my letter of 13th inst. You write as if I had advocated the immediate introduction of an accumulator into every separate consumer's premises; but this was not my meaning. I do not propose that the whole general supply shall be through accumulators, and I said the day load was to be "looked for," not to be *at once* had, "in a large extension of the use of accumulators close to the lamps;" though I certainly think the time for this extension is very near. I added that "where circumstances suited, of course, the battery might be arranged to supply a group of houses." My idea is to get the battery on consumers' premises, so as to have it as near as possible to the lamps (and thus reduce the cost of mains to a minimum), and save the rent of premises for sub-stations.

To meet your point as to the amount of capital required, I proposed that consumers should pay 5 per cent. interest thereon. It seems to me that the whole question of the extended use of accumulators is a matter for special consideration in each case, depending very largely upon the price at which current can be supplied at times when the direct demand is small.

Now, as to cost of maintenance: the coming average should be at least equal to the past best, and as the E.P.S. Company now undertake contracts for maintenance at from 5 to 15 per cent., averaging "under 10 per cent.," my estimate of 7½ per cent. in the near future does not seem to me out of the way. To test the matter I have written to the Epstein Company asking for information as to first cost and maintenance that I might make use of, and they reply:—"For the supply of a large number of batteries your estimate of the cost, viz., £2 per lamp is rather over than under the mark, and even if many small-capacity batteries be distributed throughout the electrically lighted area as mentioned in the editorial, we would have no hesitation whatever to undertake their maintenance for an unlimited period at the rate of 7½ per cent. per annum on their net invoice value."

The cost of a small E.P.S. battery, allowing what seems a not unlikely discount for a large order, works out as follows:—

	£	s.	d.
55 K13 cells, glass	143	0	0
Trays and insulators	5	14	7
Glass sheets	0	13	9
Stands	8	11	0
Erection	4	5	0
List price	162	4	4
Deduct for trade, cash and contract discounts 20 per cent.	32	8	10
Net cost of battery	129	15	6

This battery would be capable of running 64 60-watt lamps for nearly five hours. Larger batteries would make a somewhat better showing.

But here another consideration comes in; after next November it is practically certain that, with lamps at a fourth or fifth of their present prices, they will be run at a higher efficiency, and an allowance of 3 watts per candle-power will be a safe one. (The Zürich Incandescent Lamp Company are now advertising central-station lamps at 2·6 to 2·7 watts per candle-power.) This will reduce the cost of accumulators for any given amount of light by 20 per cent., as compared with the foregoing.—Yours, &c., W. S. BOULT.

60, Castle-street, Liverpool, June 20, 1893.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1893 Edition of "THE ELECTRICIAN" Electrical Trades' Directory and Handbook is NOW READY. This useful book contains over 1,000 pages, and several new and handy features have been added. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

TENDERS INVITED.—The Urban Sanitary Authority for the district of Ealing invite tenders for—(1) Engine and boiler-house, buildings, &c., and accessories; (2) the provision and laying of mains, transformers, and accessories; (3) the wiring of public buildings, provision of fittings and accessories. Further information will be found in our advertisement columns, and plans, specifications, and all other complete particulars, can be obtained of Messrs. Bramwell and Harris, engineers, 5, Great George-street, Westminster, S.W.; or of Mr. Charles Jones, C.E., Surveyor to the Local Board, Ealing. Tenders for each contract must be sent in, addressed to the Chairman of the Ealing Local Board, before 12 o'clock, on Tuesday, July 18th next.

——— Tenders are required for the lighting by gas or electricity of the city of Belem, Gram Pará, Brazil. Particulars can be obtained at the Brazilian Consulate, 6, Great Winchester-street, London, E.C.

TENDERS ACCEPTED.—The Cardiff Lighting Committee on Monday had under consideration the tenders received for the supply of machinery and apparatus for an electric lighting central station. Out of 26 tenders received eight were from firms offering to supply everything required; but Mr. Massey, the electrical engineer, said that by dividing the contracts a sum of about £200 would be saved, and the following tenders were therefore accepted:—Messrs. Davey, Paxman, and Co. (Colchester), boilers; Messrs. James Watt and Co. (Birmingham), condenser; Messrs. Siemens Brothers and Co., Limited (London), dynamos, switchboard, transformers, &c.; Messrs. Johnson and Phillips (London), lamps and cut-outs. The total amount of the accepted tenders is £10,242, but the consideration of the tenders for lamp posts having been deferred, about

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another £200 will eventually be added to this total. The tenders for the whole of the machinery and apparatus were as follows :—

John Fowler and Co., Leeds (Limited), without boilers...	£11,600
S. Z. de Ferranti (Limited)	12,700
Brush Electrical Engineering Company (Limited)	12,200
Latimer Clark, Muirhead, and Co. (Limited)	11,500
Crompton and Co. (Limited)	11,200
Johnson and Phillips	11,000
Siemens Bros. and Co. (Limited)	10,900
Woodhouse and Rawson United (Limited)	10,800

TENDER ACCEPTED.—The Holborn District Board of Works have accepted the tender of Messrs. Verity and Sons for the electric lighting of the Town Hall, the amount being £400.

BANKRUPTCY.—The public examination of Mr. William M'Whirter, lately carrying on business at Govan as an electrical engineer, was held on Friday, when the trustee stated that he had received full explanation regarding the estate, and he had no further questions to ask. The bankrupt's examination was closed.

DEED OF ASSIGNMENT.—Messrs. Austin and Myers, trading at Florence Works, Amberley-road, Armley (Leeds) as manufacturing electricians and electrical engineers, have made an assignment of their property for the benefit of their creditors. The liabilities are given as secured and partly secured, £275 ; unsecured, £270. 7s. 2d. ; whilst the assets are returned at £90. Mr. Thomas Grisdale, 37, New-street, Huddersfield, is the trustee. The creditors over £20 are as follows :—

Joseph Longley, Bradford	£275
Joseph Gration, Leeds	24
Samuel Greaves, Leeds...	70
Alabaster, Gatehouse, and Co. (*Electrical Review*), London...	47
Industries (Limited), London	38
Walter F. Glover and Co., Manchester	21

FOWLER, LANCASTER, AND CO. (LIMITED).—The petition for a winding-up order against this Company was last week, by consent, dismissed without costs. The Petitioners, the Electrical Company (Limited), desired an arrangement to protect the unsecured creditors in the voluntary liquidation, and a gentleman had been appointed with whom they were satisfied.

BIRMINGHAM TELEGRAPH FACTORY (LIMITED).—Judge Chalmers resumed the adjourned examination into the affairs of this Company, at the Birmingham County Court, on Thursday last week. The hearing had been postponed in order that affidavits might be prepared, and an opportunity given for the cross-examination of certain Directors of the "Factory." These affidavits were now read, and Mr. Fowler was cross-examined as to £3,000 worth of shares in the "Factory," held by certain of the Directors of Fowler, Lancaster, and Co. The "Factory" was indebted to Fowler, Lancaster, and Co. at the time the shares were allotted, the Directors being trustees on behalf of the latter Company. It was argued, on the one side, that these shares were given as a set-off, and were therefore paid for ; and on the other hand that the trustees were liable to pay for the shares and thus become contributaries to the estate of the Company. At the end of the arguments his Honour reserved judgment.

THOMSON-HOUSTON INTERNATIONAL ELECTRIC COMPANY.—Our advertisement columns contain a notice that Mr. W. S. Graff-Baker, who has represented the traction interests of the above Company in England for some years past, has severed his connection with the Company, in order that he may devote the whole of his time to the business of the Electric and General Contract Corporation, of which he is Managing Director. Future communications intended for the Thomson-Houston International Electric Company should be addressed to the European offices, 27, Rue de Londres, Paris ; or to 38, Parliament-street, London, S.W., where the Company continues to carry on business.

LEA, SONS, AND CO.—This firm send us an advance copy of their new electric light fittings catalogue and price list. The catalogue is in single sheets, so that the prices of fittings required for any special purpose can be readily obtained. Many of the designs are in the very best taste, and as proof of the care with which the sheets of illustrations have been prepared, Messrs. Lea, Sons, and Co. inform us that the sheets of designs are hand-painted. The list is in every way a very handsome production.

MESSRS. GILBERT AND CO.—This firm have secured the contract for the electric lighting of the large Philharmonic Restaurant at Cardiff.

MESSRS. SHIPPEY BROS.—This firm inform us that they have been made agents for the National Electric Manufacturing Company. Their new catalogue includes alternators, transformers, and electric lighting fittings, and the usual large variety of apparatus which goes to make up an American "system." The alternators appear to be not unlike the Westinghouse, with smooth cores and cast-iron fields.

DISTRICT MESSENGER AND ELECTRIC CALL COMPANY (LIMITED). Some particulars are published of the amount of business being done by this Company, and it appears that nearly 12,000 houses in London are connected by the electrical call apparatus belonging to the Company. An interesting account of the Company's business is given in a recent issue of *Cassell's Saturday Journal*.

ELECTRICAL CRANES.—We have received from the Ateliers de Construction, Oerlikon, Zürich, their latest catalogue of electrical cranes and hoists. A number of illustrations accompany the list, which is in German.

MESSRS. RUSSELL AND CO.—The *employés* of this firm had their annual holiday on the 17th inst. The entertainment provided consisted of a trip on the river in a steam launch, with dinner at Staines, and tea at Kingston.

ABERDEEN.—A meeting of the shareholders of the Northern Co-operative Company (Limited) was held on Tuesday last to consider the question of the electric lighting of their central premises. The Buildings Committee had reported that Prof. Kennedy estimated the cost of the machinery and apparatus necessary for supplying 500 8 c.p. lamps, exclusive of wiring, at £625, and that the annual cost would be about £260. The Committee did not think there would be much difference between the cost of the electric light and gas ; but, taking into account the greater amount of light from the electric current, and the absence of heat, and deterioration caused to goods by the fumes of gas, they unanimously recommended the Company to adopt the electric light. Some discussion ensued, and in the end the consideration of the matter was adjourned.

ADELAIDE (SOUTH AUSTRALIA).—At a recent meeting of the Municipal Corporation the report of the Committee appointed at the Postal and Telegraph Conference held at Hobart in 1892, for the purpose of drafting a code of rules and regulations for erection of electric light and power wires was read and considered, and the Committee recommended that in any scheme adopted by the Council for lighting the city street lamps by electricity the Council should insist on the regulations drafted by the above Committee being strictly adhered to. A scheme is on foot to introduce the electric light into the public streets.

A MILITARY TELEGRAPH CAMP.—The *Daily Graphic* of Wednesday contained an illustrated description of the work done by the Telegraph Battalion of the Royal Engineers at their annual training and drill in the Duke of Norfolk's Park at Arundel.

BALLARAT (AUSTRALIA).—Mr. Lee Murray has presented a report to the City Council of Ballarat regarding the lighting of the district by electricity. He estimates the total cost of the generating plant at £25,105, and the interest on outlay and maintenance at £4,825 The matter is under the consideration of the City and Town Councils

BARNET.—On Tuesday last a Parliamentary Paper was published in reference to the Electric Lighting Provisional Order which the Barnet Local Board has applied for in order to keep out outsiders. Lord Playfair has given notice of an amendment to Clause 6, to be moved on the third reading of the Bill dealing with this and similar orders. "Provided always that if the undertakers or any such owner at any future time apply to Parliament to repeal or amend the foregoing provisions in accordance with the report of a joint committee of both Houses of Parliament (whether such report shall or shall not be retrospective in its recommendations), such owner or the undertakers, as the case may be, shall not be entitled to oppose such application except on details." The matter was discussed at the Local Board meeting, and was unanimously approved, Mr. Morse saying that it was of a valuable character.

BECKENHAM.—At the last meeting of the Local Board letters were read from the Board of Trade stating that they proposed to release to the Crystal Palace and District Electric Supply Company (Limited) the deposit made by them under their Order, and the Board proposed to issue a licence to the Company in respect of the extended area of supply conditionally acceded to by the Local Board. The clerk explained that the Company had obtained one Provisional Order to supply a part of the district of the Local Board, and they now desired to extend that district, for which a second Provisional Order would be necessary, but the Board of Trade had decided not to grant this second Order unless the Company consented to the insertion of a clause which would enable the Local Board to purchase the Company's undertaking in this extended district.

BEDFORD.—At their last meeting the Urban Sanitary Authority had under consideration the report of the Electric Light Sub-Committee, recommending the acceptance of the tender of the Bedford Electric Light Company to undertake and carry out the Provisional Order which has been obtained. After considerable discussion, it was decided to refer the report back to the Sub-Committee, in order that they might treat with the Company, and further report.

BRIGHTON.—At the last meeting of the Board of Guardians a discussion arose on the question of the rental paid by the parish to the National Telephone Company for the use of the telephone.

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The Chairman said the Telephone Company had recently altered their regulations, and that call office subscribers had now to pay a penny or deposit 5s. for a key before they were allowed the use of the telephone. The clerk pointed out that these regulations only referred to call offices. Mr. Bennett said he believed the regulation was put in force with the view of ultimately abolishing the call offices altogether.

CARLISLE.—Messrs. Siemens Brothers are laying conductors for private lighting, and considerable progress is also being made with the cables for public lighting. The southern portion of the town is practically completed.

CITY OF LONDON.—The electric lighting of the Guildhall is to be extended to the museum, at an estimated cost of £360.

DUNDEE.—At the annual meeting of the Dundee Gas Commission, held last week, it was stated that the electric light had received a fair amount of support from the public, and was giving satisfaction. It was decided to reduce the price of gas by 5d. per thousand, and the price of the electric current was fixed at 5d. per unit. A communication asking the Dundee authorities to join several large English towns in a Parliamentary representation respecting the vexed question of tramways and telephones was mentioned, and it was agreed that as Dundee was not directly interested it was unnecessary for the Commission to take any action.

HADDINGTON.—The question of renewing the lease of the East Mill, the property of the Council, came before that body at their last meeting, and Mr. Falconer stated that, as there was a possibility of the town being lit by electricity the power of the water at the East Mill might be utilised for that purpose. It was agreed to postpone any decision for a time. An inquiry is meanwhile to be made as to the strength of the water power, and whether it would be sufficient for the purposes of the electric lighting scheme.

LANCASTER.—A Local Government Board inquiry was held on Wednesday at Lancaster by Major-General Crozier, R.E., in connection with the application of the Corporation for power to spend £25,000 on the electricity supply. Mr. W. Geipel, M.I.E.E., attended on behalf of the Brush Company, and explained the details of the scheme. The system adopted is the three-wire low-tension continuous current, with a set of storage-cells for the day load. Three direct-driven two-pole dynamos are being made at Falcon Works, the whole of the installation being in the hands of the Brush Company.

LAMBETH.—The Board of Guardians have decided to obtain an expert's opinion as to the practicability, cost, and ultimate economy of lighting the Renfrew-road Workhouse and Infirmary by electricity.

LLANGOLLEN.—Mr. C. L. Hett, hydraulic engineer, has submitted his report on the proposed scheme for utilising the water-power of the river Dee for the electric lighting of Llangollen. He reports that with an additional 5ft. fall at the Llangollen Mill there would be sufficient power to light the town, that no alternative steam power would be required, and that this would not, under ordinary circumstances, interfere with the working of the mill. Mr. Hett estimates the total cost of the water-power installation to be £3,000.

LONDONDERRY.—Satisfactory progress is being made with the building of the central station in Strand-road. The whole of the work, including the laying of the street mains and the erection of the lamp pillars, is to be finished during the month of September.

MAIDSTONE.—The Town Council had before them at their last meeting the report of the Electric Lighting Committee, which stated that they had advertised for information as to the terms on which a company or firm would undertake and carry out the powers granted under the Maidstone Electric Lighting Order, and that of the five replies received they were of opinion that the terms offered by Messrs. Sharp and Kent and Messrs. Bourne and Grant were the most favourable. Messrs. Sharp and Kent proposed to undertake the whole of the public lighting, the Local Authority guaranteeing a minimum sum per annum of £500. The Authority would have the right to purchase the undertaking at the end of ten years by paying for the plant and five times the previous year's net profit for the goodwill. The Authority would be required to find a suitable site for the works, for which Messrs. Sharp and Kent would pay an agreed rental. A discount of 25 per cent. from the maximum rate charged to be allowed for public lighting, a minimum annual payment to be guaranteed. Messrs. Bourne and Grant would agree either to an absolute transfer to them of the Order or would enter into a contract. In the former case the firm would submit a working scheme for the approval of the Authority, and the Authority would have the option of purchasing the undertaking at the end of 21 years; if a contract were entered into the Authority would undertake to purchase the undertaking in 21 years. After some discussion the whole matter was referred back to the Electric Lighting Committee for further consideration. It is still possible, however, that the Local Authorities will keep the Provisional Order in their own hands.

MANCHESTER.—The application of the National Telephone Company for leave to lay their wires underground came before the last meeting of the City Council, and after considerable discussion it was resolved, "That the Paving, Sewering, and Highways Committee be authorised to negotiate with any telephone company or private owners, or the Postal Department of the Government, on the subject of underground telephone wires; that before carrying any arrangements into effect the Committee be requested to present a special report to the Council, and that until such report has been considered and sanctioned by the Council no arrangement whatever be entered into by the Corporation."

MELBOURNE (VICTORIA).—At a recent meeting of the South Melbourne City Council the Mayor intimated that he, with the City Surveyor, had recently met in conference with the mayors and surveyors of the St. Kilda and Prahran councils, with the view of ascertaining the best means of lighting the streets of the three cities, the gas supply being of such an inferior character. Councillor Smith, M.L.A., expressed an opinion that the matter was a very ticklish one, and should not be touched at present. Lighting the streets by electricity had been tried in several places, and had not always proved a success. He thought that as the City Corporation of Melbourne was expending a large amount of money to try the experiment it would be well for the South Melbourne Council to await the issue. After a brief discussion it was resolved to submit the matter to the consideration of the Legislative Committee.

NEWCASTLE (N.S.W.).—The City Council, at a recent meeting, decided to take over the electric plant from the contractors for the sum of £9,250.

NORWICH.—It will be seen from the report in another column of the recent meeting of the Norwich Electricity Company (Limited) that the Directors have decided to charge half-price for electric current *after* eight o'clock in the evening. We understand that the Directors have, in consequence of an application from the trustees of a place of worship using the electric light, decided to allow the reduced rates to commence at 7 o'clock on Sundays. It is anticipated that this concession, which will make electric light compare very favourably in point of cost with gas, will bring about the general use of the former illuminant in places of worship in the district.

OSWESTRY.—The Town Council will on July 17th consider an adjourned application from the Oswestry Electric Light and Power Company (Limited) for the Council's sanction to an intended application to the Board of Trade for a licence.

ORPINGTON.—A scheme has been prepared by Mr. J. Torr Todman for the electric lighting of Orpington. He proposes to use the high-tension alternating current at 2,000 volts for the main current, to be reduced to 50 or 100 volts for the sub-circuits. The central station would be at a place known as Hodsell's Mill, where sufficient power could be obtained from existing steam engines to run 250 16 c.p. lamps, which, with additional boiler power, might be increased to 350 or 400. The estimated cost of the plant, laying mains and branch cables, and fixing transformers, is £905, and the annual working expenses are put down at £277, which it is calculated would be well covered by the receipts. The Orpington Committee of the Bromley Rural Sanitary Authority have recommended that all facilities should be given for the supply of the electric light to the district and that the necessary permission be given for breaking up the roads.

ST. LUKE'S (CHELSEA).—The Board of Trade have revoked the St. Luke's (Chelsea) Electric Lighting Order, 1891.

SEAHAM HARBOUR.—The members of the Seaham Harbour Co-operative Society have decided to light their very extensive premises by electricity.

SOUTH STONEHAM (HANTS.).—The tender of Mr. Thomas Glyde, of Sir George's-road, Freemantle, was accepted for making electric communication between the infirmary and the workhouse, at £4. 9s.

YORK.—The Electric Lighting Sub-Committee have had under consideration the several tenders for the lighting of the city by electricity. The majority of the tenders were from companies adopting the high-tension system, and the Sub-Committee recommended the adoption of one of these tenders. At a meeting of the full Committee, however, it was deemed advisable that a digest should be prepared of Prof. Kennedy's reports, so that they would be in possession of the main features of both the high and the low-tension systems. When this digest is prepared the full Committee will meet and finally decide.

BOOKS RECEIVED.

"Electric Light Installations." By Sir David Salomons, M.A. Vol. I. Revised and enlarged. (London: Whittaker and Co.)

Journal of the Franklin Institute. June, 1893. (Philadelphia: The Institute.)

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ELECTRICAL TRACTION AND LIGHTING ON TRAMWAYS.

A special meeting of the Tramways Institute was held yesterday, at the Holborn Restaurant, under the presidency of Mr. W. J. Carruthers Wain, the President. The formal business of re-election of the President, Vice-Presidents, and Executive having been completed,

The SECRETARY (Mr. J. G. B. Elliot) read the report of the Council, which stated that at the Birmingham meeting the members had the opportunity of inspecting the new electric installation by means of overhead wires on a portion of the South Staffordshire line, from Wednesbury to Walsall and Bloxwich and to Darlaston; and at Liverpool the privilege of inspecting the Liverpool Overhead Electric Railway. The Council were gratified at the success which had attended their efforts to introduce to the notice of members all the newest developments of the application of modern science to traction. The matters discussed at these two meetings included, amongst others, electric traction by overhead wires and the claims of telephone companies and their opposition to electrically-worked tramways. The most important events of the year, from a traction point of view, had been the opening of the South Staffordshire Electric Tramways and the Liverpool Overhead Electric Railway.

The PRESIDENT, on moving the adoption of the report and accounts, said that as regarded electrical traction this country did not show the progress that had been made by other countries. Taking the United Kingdom they had had 33 miles of electric tramway built during the 10 years since the first electric line was opened in 1883, viz.: the Portrush and Giant's Causeway. In America the idea of electric traction was only taken up in 1887, but since that time their convenience had been so realised that there were at the present time no less than 436 miles of electrical lines, with 3,532 miles of track, and 5,581 cars carrying 250,000,000 passengers annually. This only showed what could be done in countries where there was freedom and not annoying restrictions (hear, hear). He moved the adoption of the report and accounts.

Mr. MASON seconded the motion, which was carried.

Mr. L. EPSTEIN then gave particulars in regard to "Recent Results of Accumulators (Electric Traction)." He stated that the use of the accumulators supplied by his firm to the Birmingham Central Tramway Company had proved very satisfactory, and he asked the corroboration of the President, who was the Chairman of that Company, as to the facts.

The PRESIDENT said that the assertion of Mr. Epstein was accurate, and under severe difficulties of gradients and snowy weather the result had been most satisfactory.

In reply to questions, Mr. EPSTEIN said that the accumulator system was cheaper than the overhead or conduit system of electric traction.

Mr. H. U. WOLLASTON then dealt with a Paper upon the lighting of omnibuses and tramcars, and the Bristol electric lamp for this purpose was also submitted to the meeting by Mr. Edwin Freund. The Papers stated that electricity could beat gas in the matter of price for this purpose.

After some discussion, a vote of thanks to the President closed the proceedings.

COMPANIES' MEETINGS AND REPORTS.

Electric and General Investment Company (Limited).

The fourth ordinary general meeting of the shareholders of this Company was held at Winchester House, Old Broad-street, on Tuesday, under the presidency of Mr. George Herring.

The SECRETARY (Mr. J. Cecil Bull) having read the notice calling the meeting, the report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, I am sure, if all the shareholders were present they would fully agree with the Directors in regretting the loss of their former Chairman, the Duke of Marlborough, and, speaking for myself, I can only say that I felt the loss very much indeed of the cleverest man I ever met. I do not think I need detain you on the report, for it simply goes through the balance-sheet, and mentions the fact that I have been elected Chairman. I will now proceed to the balance-sheet. The first item I will deal with is the capital account, and I call attention to that to show you how it is that we are enabled to make the dividend we recommend. We have an authorised capital of £200,000, a subscribed capital of £100,000, and a paid-up capital of £20,000, so that, in plain language, we have good credit and a small capital to pay a dividend on. I cannot better illustrate that than by our present dividend, which is £6,000, or sufficient on our authorised capital to pay only 3 per cent., on our subscribed capital 6 per cent., and on our paid-up capital 30 per cent. Therein is the great secret of our success, as I said before. The next item is the reserve fund of the holders of the founders' shares. That is invested by the Directors in a manner which, they think, will ultimately turn out to the advantage of the founders. The reserve fund of the Ordinary shareholders is invested in the business of the Company. There is a loan account of £20,000, but there is a loan on the other side of the balance-sheet of £14,000, so that there is a loan account of only between £5,000 and £6,000. The sundry creditors are the usual creditors for the time being, most of whom would be paid within a fortnight. The item of "unclaimed dividends" speaks for itself, as does also the item of profit and loss account. I will mention the dividend further on. I will now turn to the other side of the balance-sheet, and the first item there is "investments at cost." We have placed it in that manner for the sake of our convenience, but we had made an estimate, and as I know that the item of "investments at cost" is always likely to provoke an inquiry in the shareholders' minds whether they are worth that money or not, I can assure them that our investments are worth that price, even at the present depressed quotations. The "loan against security" is more a matter of book-keeping, there is a liability attached to it, which, however, is fully covered. "Sundry debtors," amounting to £1,356, are all good. "Cash on current account at bankers" speaks for itself; and the "founders' reserve fund" I have already spoken of. Passing to the profit and loss account, "the general charges, including Directors' fees and their additional remuneration, &c.," have been £3,164 for the past year. In our first report that item only amounted to £1,000, but it is *not* a subject of congratulation that it should be £1,000. It is a subject of congratulation to the shareholders when this item mounts up, because when it does it means that more business is doing, and also that we, your Directors, get an additional remuneration—a certain percentage on the profits—after you have received your 10 per cent. Therefore, it is to your distinct advantage to see that item mount up. The interim dividend you have already received, and the balance is £5,928, making, united with the £137, the balance from 1892, the sum of £6,065 which we now have available for distribution. I do not think I will occupy you any longer. I might call your attention, however, to the fact that in the last three years, during which we have been established, we have returned you nearly 12s. 6d. out of every sovereign you invested, and we have also put to the reserve fund 10s. We have therefore earned nearly 22s. 6d. already for every pound you have invested in this Company. I think you will agree with me and the Board that we have reason to be proud of our success, and I hope you will say that the Directors have deserved the remuneration they receive. Of course, if we have a good prosperous year, we should earn more dividend, but in bad years we may earn less, and I should like to give you this word of warning—that the mere fact of your receiving 25 per cent. per annum shows that, to a certain extent, it is more or less speculative, and when a bad year comes I hope that you will not reproach us. I do not anticipate a bad year, but one might come. If we have prosperous years the public might be inclined for electrical investments. We have one which we shall bring out, and I believe that even in these depressed times it will go down well, but I am perfectly sure that in good times it would be subscribed for four or five times over. I will now move "That the report of the Directors and the statement of accounts to May 31, 1893, with the appropriation of the surplus profits as proposed, be and the same are hereby received and adopted."

Mr. J. B. BRAITHWAITE, Junr.: I have great pleasure in seconding the adoption of the report and accounts. I can only endorse what the Chairman has said—that we believe our balance-sheet is a thoroughly sound one, especially the item of "investments at cost," which is usually the item in which, if there is anything unsound, it is wrapped up. I can thoroughly endorse what the Chairman says, however—that we believe our investments to be worth to-day, even in these depressed times, all that we gave for them, and that we could realise them for fully the sum at which they stand in the balance-sheet.

The CHAIRMAN then put the motion, and it was carried unanimously. He afterwards proposed the following resolution:—

"That a dividend at the rate of 30 per cent. per annum for the half-year ended May 31, 1893, making, with the interim dividend of 10 per cent. paid for the six months ended November 30, 1892, 25 per cent. for the year, be and the same is hereby declared on the capital paid up on the Ordinary shares, that a dividend of £30 be declared on each Founders' share, and that the respective dividend, be paid on July 1, 1893."

The Right Hon. Lord CLONCURRY briefly expressed his pleasure in seconding the resolution, which was carried unanimously.

Mr. B. H. VAN TROMP: It is my pleasing duty to propose the re-election of Mr. Joseph Bevan Braithwaite, jun., and Lord Cloncurry as Directors of this Company. I think you have special evidence in the balance-sheet before you and in the admirable speech from the Chairman that your business is thoroughly well-conducted by your Board, and I will ask you, therefore, unanimously to re-elect these two gentlemen as Directors.

The MANAGING DIRECTOR (Mr. Emile Garcke) seconded the motion, which was unanimously adopted.

A resolution was afterwards passed re-electing Messrs. Rait and Kearton, auditors of the Company, for the year ending May 31, 1894, at a fee of 50 guineas.

Mr. KEARTON, in acknowledging the re-election of his firm, said he hoped it might be his pleasing duty in the future to audit such accounts as those now submitted to the shareholders. He had received all the information he had asked for, and had been met all through with the greatest consideration. He had sometimes thought he had been regarded as a bother, but his desire had been to get at the bottom of everything in connection with the accounts.

The proceedings then terminated.

Norwich Electricity Company (Limited).

The second ordinary general meeting of this Company was held on the 17th inst., at the office, Queen-street, Norwich, Mr. F. W. Harmer presiding.

The CHAIRMAN, in moving the adoption of the report, said the Board were glad to announce that the works would be in full working order in a short time. The Directors had not been ready to start before, because it was a case where, had they taken more haste, it would certainly have resulted in less speed. They determined, before they spent the money

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which had been entrusted to them, to make every inquiry that was possible in order to ascertain, from the experience of other places, the best way of dealing with the difficult problem they had to solve. That it was a difficult one was shown by the fact that the Corporation had determined, after very careful consideration, to leave the question of electric lighting alone. There was no such general consensus of opinion among electricians, either as to the best principal of producing and distributing electricity or as to the most suitable machinery and apparatus to use for that purpose, that would have justified the Directors in proceeding otherwise than with the greatest caution. There was hardly any detail to which they had not given the closest personal attention, and they had taken no important step without getting the best scientific advice within their reach. The arrangement which the Directors had made with Messrs. Laurence, Scott, and Co., to carry on and develop the business of electric lighting in the city until the Company was ready to start, had worked well. Since the beginning of the present year the number of lamps installed had nearly doubled, and thus the Company would commence its operations with a guaranteed income for the first year. Although the work of the last few years had cost them a great deal of labour and anxiety, the Directors did not at present ask for any remuneration, as their great desire was to make the Company a success, but when it became so, as he had no doubt it would before long, they felt they might leave it to the shareholders to vote them such a sum as they might think they had earned. Replying to questions, the Chairman said that the normal price for the electric light in Norwich was 8d. per unit, and he doubted whether it could be produced here, at any rate at first, at less than that figure. The Directors had, however, at the suggestion of Messrs. Laurence, Scott, and Co., determined to try the experiment, which he believed had not been adopted elsewhere, of charging half-price to any person who desired to take the current after the general demand for the light had ceased. One of the great expenses of electric lighting was that of getting up steam; when the steam was once got up it cost comparatively little to run the machinery an extra hour, and they were willing that all their customers should share in the advantage of getting in this way light at a reduced price which it would cost them less to produce.

The report having been adopted, the retiring Directors and auditor were re-elected, and the proceedings terminated.

The Directors' report included the following:—

"After much inquiry as to the respective merits of the different systems of electric lighting, and their adaptability to the conditions of Norwich, including personal visits to many of the stations which are at work successfully in different parts of the country, the Directors finally arranged with Messrs. Laurence, Scott, and Co., of this city, to carry out, on advantageous terms, plans which they had prepared with the assistance of Prof. Henry Robinson, C.E., the consulting engineer of the St. Pancras Vestry. The Directors have purchased, on favourable conditions, an admirable site for their central station, near Duke's Palace Bridge, which fulfils all the conditions necessary for the economical production and distribution of electrical energy, and is large enough to give ample room for future expansion. Buildings have been erected on this site, and the necessary machinery is now being laid down in them. In selecting and purchasing this machinery, and in carrying out the works generally, the Directors have endeavoured to take advantage of the experience of towns which were earlier in the field, and they hope, as a result of this, that when it is completed the shareholders will find themselves in possession of apparatus of the newest and most efficient kind. The Directors believe the work of the contracting engineers has been carried out in a careful and substantial manner. Messrs. Laurence, Scott, and Co., having been for some years supplying electric light and power in the city, the Directors thought it desirable in the interest of the Company to arrange with them to continue to do so until the Company was ready to start working. The experience of other towns shows that as soon as electrical stations are started the demand for light, &c., rapidly increases, and the inquiries which the Directors are now receiving are such that they believe that their present machinery will not long be sufficient to supply the needs of their customers. They propose, therefore, to offer to the public a portion of the shares at present unissued."

Electricity Supply Company for Spain (Limited).

The fifth ordinary general meeting of the shareholders of this Company was held on Monday at the offices, St. Helen's-place, Lord Castletown of Upper Ossory, in the chair. A correspondent sends us the following account of the proceedings:—

The report presented by the Directors for the year 1892 stated, *inter alia*, that the balance of the debt due to Messrs. C. de Murrieta and Co. (Limited) has been liquidated all but a small sum of about £220 by the issue to the receivers and managers of the £40,000 Second Mortgage Debentures. During the year a large sum has been spent on improving the position of the Company by further canalisation, and by the installation of meters and converters, which has been found necessary owing to the increased demand for electricity. The profit and loss account shows a net profit in Madrid of £7,084. 2s. 5d., as against a loss of £1,229. 10s. 7d. in 1891. Including interest on debentures and London expenses the balance at the debit of profit and loss is £2,055. 13s. in 1892, as against £8,457. 6s. 7d. in 1891. Early in the present year a change was made in the management at Madrid, and Mr. H. E. C. Clarke was appointed to carry on the affairs of the Company in Madrid in the place of Señor Gonzalez. Mr. Chisholm was appointed Chief Engineer of the Company in the place of Mr. Robinson. Mr. Chisholm was the engineer by whom the electric light station and all its machinery was erected, and he has had considerable experience in the working of the particular system in use. Many economies have been effected in the general management of the business both in the office and in the works, by a reduction in the staff, and by a considerable saving in the quantity of stores used.

The CHAIRMAN referred with satisfaction to the improvements in the Company's business, which he showed by comparing the working one year with another, and also month by month. There had been a large increase in the gross revenue, in the number of lamps placed, and in the number of consumers. The growth of their business had, in fact, been so great that it had become necessary to issue the £25,000 Prior Lien Bonds, which they were now placing in order to meet the increased demands upon them. Referring to the accounts, he stated that there were certain exceptional items last year, amounting to £1,300, and if these had been eliminated the net loss would have been reduced to £700. With reference to the present year, the current sold during the first four months showed a very large increase as compared with the corresponding period of 1892, and since the last report the number of lights installed had been largely added to. It had, therefore, become absolutely necessary to expend further capital in enlarging the works and providing further plant. He concluded by moving the adoption of the report.

Mr. E. F. G. HATCH seconded the motion, which was adopted: and resolutions were afterwards passed confirming the election as a Director of Mr. John Annan to fill the vacancy caused by the retirement of Mr. Germaine; re-electing the retiring Director, Mr. Alfred George Gillingham; and appointing Messrs. Deloitte, Dever, Griffiths, and Co., chartered accountants, as auditors to the Company, Messrs. Broads, Paterson, and Co., the late auditors, having retired in consequence of the election of Mr. Annan as a Director, that gentleman being a partner in their firm.

West African Telegraph Company (Limited).

The following is the report of the Directors to the eighth ordinary general meeting to be held at Winchester House, on Thursday, July 13th, at 2:30 p.m.:—

The Company's revenue for the twelve months ended December 31, 1892, amounted to £60.922. 14s. 2d., against which £20.018. 14s. 8d. is charged for ordinary expenses, £13,964. 3s. 7d. for expenditure relating to repairs of cables, &c., and £802. 10s. 3d. for income-tax, leaving a balance of £26,137. 5s. 8d. From this amount is deducted £23.726. 15s. 10d. (being for interest on debentures £13.060. 2s. 6d. and for sinking fund £10,666. 13s. 4d.), leaving a balance of £2,410. 9s. 10d., which it has been decided to carry forward.

The large increase in the expenditure for repairs of cables is mainly due to the breaks that have occurred in our São Thomé-Loanda section, off the River Congo. This cable is now being diverted beyond the influence of the currents caused by the river. Although this operation will involve heavy expenses, after mature consideration this course has been decided upon as being the most economical means of avoiding the constant interruptions which have occurred at the mouth of the Congo.

It will be seen from the accounts that we have made a further loss on exchange of £8,044. 10s. 1d., for the year under review, which is chiefly owing to the continued depreciation of Portuguese currency. Negotiations are still being carried on with a view, as far as possible, to minimise the loss in future transactions.

On reference to abstract C of the report, full details will be found of the numerous repairs effected during the year. The several sections of the Company's cables are (with the exception of the interruption named) in good working order.

We record, with regret, the decease of our colleague, Sir James Anderson. Mr. John Denison Pender has been elected to fill the post of Managing Director thus vacated, and Mr. John Cambrook has been appointed secretary in the place of the late Mr. William Payton. The Director who retires by rotation is Sir Henry C. Mance, C.I.E., M.Inst. C.E., who, being eligible, offers himself for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths, and Co. also retire, and offer themselves for re-election.

United River Plate Telephone Company (Limited).

The following report of the Directors of this Company for the year ended March 31st last, is to be presented at the seventh ordinary general meeting, to be held at Winchester House, E.C., on Tuesday, July 4th, at 12 o'clock:—

After deduction of expenses in the River Plate, loss on exchange, debenture interest, and other London charges, the Directors are pleased to report that the year's working has enabled them to write off £768. 7s. 8d., the balance of taxes suspense account, £2,728. 12s. 9d. for bad and doubtful debts, and to carry £3,000 to depreciation and renewal fund. There then remains a balance of £540. 3s. 3d., increased by £365. 9s. 9d., brought forward from the previous year to £905. 13s. The capital expenditure for the year amounted to £5,394. 10s. 9d., and the working expenses in the River Plate were, at par of exchange, £57,668. 19s. 2d., against £53,618. 9s. 8d. in the previous year.

Since March 31st last the business of the Company has kept pace with the general improvement in affairs in the Argentine Republic; it is expected that this improvement will continue and that the Company will soon be in a position to resume payment of dividends.

The Board desire to express sincere regret at parting with their esteemed colleague, Mr. J. Owen Unwin, who, in order to effect a reduction in the number of Directors, which has been for some time contemplated, has resigned his seat at the Board. Under the Articles of Association, Mr. Frank W. Jones and Mr. Frederick Green retire, and being eligible offer themselves for re-election. The auditors, Messrs. Cooper Brothers and Co., also retire.

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Electric Construction Corporation (Limited).

An extraordinary general meeting of this Company will be held at the Cannon-street Hotel, E.C., on Wednesday, July 5th, at three o'clock, for the purpose of considering, and, if thought fit, passing the following resolutions as special resolutions, viz. :—

1. That it is desirable that the Corporation be reconstructed, and that with a view to such reconstruction the Corporation be wound up voluntarily.

2. That the Liquidators be, and they are hereby, authorised to consent to the incorporation of a Company (hereinafter called "the new Company") with the name of "The Electric Construction Company (Limited)," or such other name as the Liquidators may approve.

3. That the capital of the new company be £400,000, divided into 150,000 Ordinary shares of £2 each, and 50,000 Seven per Cent. Cumulative Preference shares of £2 each.

4. That the Memorandum and Articles of Association of the new Company be in such form as the Liquidator shall approve.

5. That, in accordance with the provisions of Section 161 of the Companies Act, 1862, the Liquidators be, and they are hereby, authorised to transfer to the new Company, as from July 1, 1893, all the assets and undertaking of the Corporation, upon the terms that the new Company shall pay or satisfy all the debts and liabilities of the Corporation, including the costs of the winding-up and reconstruction, and shall issue to the holders of the First and Second Mortgage Debentures of the Corporation First and Second Mortgage Debentures of the new Company of the same nominal amount, and carrying the same rate of interest as the First and Second Mortgage Debentures of the Corporation, and ranking as first and second charges respectively upon the undertaking, property, uncalled capital, and assets of the new Company, such First and Second Mortgage Debentures to be in such form, and to be secured by such Trust Deeds as the liquidators shall approve, and upon the further terms that the new Company shall issue to the Liquidators, or as they may direct, 120,000 fully-paid Ordinary shares and 14,630 fully-paid Preference shares of the new Company.

6. That the 120,000 fully-paid Ordinary shares of the new Company be distributed as follows :—

(*a*) To the holders of Income Bonds of the Corporation two shares for every £10 of Income Bonds in satisfaction of such bonds.

(*b*) To the holders of Founders' shares of the Corporation two shares for every Founders' share.

(*c*) To the holders of Ordinary shares of the Corporation two shares for every Ordinary share of the Corporation.

7. That the 14,630 fully-paid Preference shares of the new Company be distributed among the holders of the Preference shares of the Corporation in the proportion of five fully-paid Preference shares of the new Company (£10) for every fully-paid Preference share of the Corporation.

8. That the Liquidators be, and they are hereby, authorised to enter into such agreements with the new Company or a Trustee for the new Company, and generally to do all such acts and things as they may think expedient for carrying the reconstruction into effect.

Notice is also given that if the above resolutions are passed they will be submitted to a second extraordinary general meeting to be called, at which meeting the Liquidators will be appointed.

The following circular has been issued to the shareholders of the Company :—

"Since the last general meeting your Directors have carefully considered the best means of placing the Corporation in a sound commercial and financial position, and they are glad to be able to report satisfactory progress in this direction. Important reductions have been made in the general expenses, the Directors have reduced their remuneration, and such further economies as will not interfere with efficiency will be introduced as opportunity offers.

"During the past year seven Directors have vacated their seats, and three new Directors have been appointed, and the Board has thus been practically reconstituted. The Directors, recognising the necessity of a commercial manager for the economical and efficient administration of the business, consider themselves fortunate in having secured as Managing Director Mr. Emile Garcke, whose experience and success as manager for several years of the Brush Electrical Engineering Company specially qualify him for the position. Mr. James Gray has recently been appointed Secretary. The Directors have also much pleasure in reporting that the important engineering and manufacturing contracts carried out by the Works Director, Mr. Thomas Parker, have not only given entire satisfaction but established for the Corporation a high reputation for excellence of design and workmanship.

"In accordance with the views expressed at the general meeting, it has been the duty of the reconstituted Board to determine, according to the best of their judgment, whether the capital of the Corporation is adequately represented by its assets, and after careful and anxious deliberation the Directors have come to the conclusion that a re-arrangement of capital by reconstruction is both expedient and necessary. This, they are of opinion, can be most advantageously carried out by the formation of a new company with reduced capital. As a consequence of the reconstruction, future profits would be applicable to payment of dividends, instead of to making good the deficiency on capital account. [Here follows particulars of the scheme of reconstruction as set out in Resolutions 2 to 8 above.] The statement below shows the present capital of the Corporation and the capital of the proposed new Company to be issued in exchange.

"The works of the Corporation at Bushbury are generally admitted to be the best of their kind in the kingdom, and the plant is specially adapted to the business, and is in very good condition. The patents owned by the Corporation are valuable, and the electro-chemical patents taken out by Mr. Parker and the technical staff especially give good promise of profitable results.

"The ability of the Corporation to carry out large and important contracts has been shown by the successful completion of the Liverpool Overhead Electric Railway, of the South Staffordshire Electric Tramways, and of numerous electric lighting contracts and other applications of electricity in London and the provinces.

"Having most carefully considered the whole position, the Directors are of opinion that the capital of the new Company will be fairly represented by its assets, and that the proposed reconstruction deals equitably with the various interests, and places the Company in a strong position for doing such an amount of profitable work as may be reasonably expected to yield a satisfactory return upon the reduced capital.

"By reason of the reorganisation of the business, which has been in progress for some months past, it is impracticable at present to give the result of the working during the portion of the year which has elapsed: but perhaps the best evidence of the confidence of the Board in the future of the Company is that several of its members have since the last general meeting acquired shares, advanced money, or otherwise supported the Corporation to an amount exceeding £30,000.

"The Board attach much importance to having the support of every shareholder.

"On behalf of the Board,
"DANIEL COOPER, Chairman.

"Worcester House, Wallbrook, E.C., June 26, 1893."

STATEMENT SHOWING THE CAPITAL OF THE ELECTRIC CONSTRUCTION CORPORATION (LIMITED) AND THE CAPITAL OF THE PROPOSED NEW COMPANY.

Capital of the Electric Construction Corporation (Limited).			Capital of the New Company to be issued in exchange.	
6% First Mortgage Debentures, in Bonds of £100 each...	£150,000	*To be exchanged for*	6% First Mortgage Debentures, operating as a first charge upon the undertaking and property of the Company, and secured by Trust Deed ... ... *Of these, £25,000 will be deposited as security, but will be available for issue.*	£150,000
6% Second Mortgage Debentures, redeemable by half-yearly drawings within 15 years, with income bond of equal amount attached, entitled upon redemption of the corresponding debenture to rank in front of the Ordinary shares, and to bear interest at a rate equal to dividend paid on Ordinary shares	100,000		6% Second Mortgage Debentures, to rank next after the First Mortgage Debentures secured by Trust Deed, redeemable by half-yearly drawings within 15 years. *Of these, £50,000 will be deposited as security, but will be available for issue.*	100,000
Income bonds	100,000	*do.*	20,000 Ordinary shares of £2 each, fully-paid in exchange for the Income Bonds ... ... *Of these, 10,000 shares will be issued and held as security.*	40,000
7% Cumulative Preference shares of £10 each	29,260	*do.*	14,630 fully-paid 7% Cumulative Pref. Shares of £2 each	29,260
Ordinary shares of £10 each, entitled to surplus profits up to 10%, and to one-half of remaining profits ...	499,000	*do.*	99,800 fully-paid ordinary shares of £2 each, in the proportion of two new shares for one old	199,600
100 Founders' shares of £10 each, entitled to one half of surplus profits after 10% has been paid on Ordinary shares	1,000	*do.*	200 do. do. do.	400
	£879,260			£519,260

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NEW COMPANIES, STATUTORY RETURNS, &c.

NORTH-EASTERN TELEPHONE COMPANY (LIMITED).—This Company was registered on the 20th inst. with a capital of £1,000, in £1 shares, to carry on the business of a telephone, telegraph, and electric light, heat and power supply company, and to manufacture, construct, purchase, or otherwise acquire, lay down, carry out, work or otherwise turn to account cables, wires, lines, stations, exchanges, reservoirs, accumulators, lamps, meters, and anything that may be required for or capable of being used in connection with the transmission of messages or with the generation, distribution, supply, accumulation and employment of electricity. The subscribers (with one share each) are:—G. H. Coates, 33, Mosley-street, Newcastle; A. O. Challoner, Benwell Lodge, Newcastle; C. Thompson, 9, Dean-street, Newcastle; G. H. Wear, Post Office-chambers, Newcastle; William Cowell, 9, Pilgrim-street, Newcastle; S. Price, 161, North-street, Newcastle; and T. Telford, 18, Wharncliffe-street, Newcastle. The number of Directors is not to be less than three, nor more than seven.

SALT LAKE AND OGDEN GAS AND ELECTRIC LIGHT COMPANY LIMITED).—This Company has been registered with a capital of £300,000, in £1 shares, to carry on in the United States of America, England, and elsewhere, and particularly in the Territory of Utah, U.S.A., the business of a gas and electric lighting company in all its respective branches, and as manufacturers of and dealers in every description of apparatus and appliances for the same. The first signatories to the Memorandum of Association are:—C. Hanley, 112, Bishopsgate-street, E.C.; J. B. Braithwaite, 27, Austinfriars, E.C.; C. J. Hamilton, Glenridge, Virginia Water; F. H. Leslie, 251, Winchester House, E.C.; T. Salt, Weeping Cross, Stafford; J. Bousted, 34, Craven-street, W.C.; H. Noel, 17, Westbourne-terrace, W. There shall not be less than three nor more than seven Directors; the first are to be elected by the signatories to the Memorandum of Association.

VALVELESS GAS ENGINE SYNDICATE (LIMITED).—This Company was registered on the 19th inst. with a capital of £15,000, in £10 shares, to acquire, develop, and turn to account certain patents, patent rights, inventions, &c., relating to gas and vapour engines, and, with a view to such acquisition, to enter into and carry into effect agreements with Joseph Day, of Bath, and with Easton and Anderson (Limited).

ARCAS PLATING COMPANY (LIMITED).—A petition for the winding-up of this Company has been presented, and is down for hearing at the Royal Courts of Justice, Strand, on July 8th.

ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—A petition for the winding-up of this Company has been presented by Sir Daniel Cooper, and is down for hearing at the Royal Courts of Justice, Strand, on July 8th. Any person who intends to appear on the hearing of the petition must communicate with Messrs. Linklater, Hackwood, Addison, and Brown, 2, Bond-court, Walbrook, E.C, not later than July 7th.

ELECTRICAL SUPPLIES AND FITTINGS COMPANY (LIMITED).—Mr. Justice Vaughan Williams on the 15th inst. ordered that the voluntary winding-up of this Company be continued, but subject to the supervision of the Court.

PIKE, HARRIS, AND CO. (LIMITED).—The statutory return of this Company, made up to and filed on May 11, 1893, records the fact that out of a nominal capital of £30.000, divided into 1,400 "A" and 4,600 "B" shares, of £5 each, 1,218 "A" and 3,600 "B" shares have been taken up. The "B" shares have been issued as fully paid, while the full amounts have been called and all calls paid (£6,090) on the "A" shares.

VOLTA ELECTRICAL COMPANY (LIMITED).—A meeting is to be held at Messrs. Rycroft and Bellhouse's, 2, St. Peter's-square, Manchester, on July 28th, at 3 p.m., to receive an account of the winding-up of this Company.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—When the annual return for 1c93 of this Company was made up, 64,242 £15 and 96.258 £7. 10s. shares were taken up, the full amount called, and all calls paid, the amount resulting therefrom totalling £1,460.565 (which includes £565 paid on 75 forfeited shares. Share warrants to the value of £1,725, comprising five shares each, and to the value of £225, comprising one share each, are outstanding, no shares having been surrendered or issued since last summary.

WESTINGHOUSE ELECTRIC COMPANY (LIMITED).—The annual return of this Company for 1893 shows that with a nominal capital of £600,000, divided into an equal number of Preference and Ordinary shares of £10 each, 18,955 Preference and 20,000 shares have been taken up, of which 15.800 Preference and 20,000 were issued as fully paid to the vendor Company. Upon 1,835 Preference the full amount per share has been called, while upon the remaining 1,320 shares a call of 10s. per share has been made, resulting in the total payment of £19,010.

WILLANS AND ROBINSON (LIMITED).—The annual return of this Company made up to April 26th, and recently filed, shows that out of a capital of £200,000 in £50 shares, 2,214 fully paid, 58 £5 paid, and 11 £25 paid shares were taken up. 980 shares have been issued as fully paid, and upon the remaining shares calls to the extent of the amount given as part of their title have been paid, the payments being £62,265.

EDINBURGH.—An extraordinary general meeting of the Edinburgh Electric Supply Corporation was held in Edinburgh this afternoon for the purpose of winding-up. The Company was established with a capital of £33,000, on the anticipation that they would be entrusted with the lighting of the city. The Corporation has resolved to take the lighting into their own hands. A resolution for winding-up was agreed to.

CITY NOTES, &c.

ANGLO-PORTUGUESE TELEPHONE COMPANY (LIMITED).—Coupons No. 11 of the First Mortgage and No. 6 of the Second Mortgage Debentures of this Company will be paid (less income-tax) by Parr's Banking Company and the Alliance Bank, Bartholomew-lane, E.C., on and after July 1st.

CENTRAL LONDON RAILWAY COMPANY.—A special general meeting of the proprietors of this Company was held on Tuesday, at 30, St. Swithin's-lane, E.C., "for the purpose of submitting 'an Act for incorporating the Waterloo and City Railway Company, and for empowering them to construct an underground railway from near Waterloo Station to Mansion House, City, and for other purposes.'" Mr. F. A. Lucas presided, and said the meeting was convened in accordance with the Standing Orders of the House of Lords. The Waterloo and City Bill contained a clause enabling both Companies to enter into a working agreement, and it was therefore necessary that the proprietors should formally approve the Bill. A formal resolution approving of the Bill, subject to such additions, alterations, and variations as Parliament might make therein, was carried unanimously without discussion.

CHATHAM, ROCHESTER AND DISTRICT ELECTRIC LIGHTING COMPANY (LIMITED).—The adjourned meeting of the shareholders of this Company was held last week, under the presidency of Mr. J. S. Benton. It will be remembered that the first meeting was held on March 21st, when a resolution to approve of certain contracts between the Company and its Chairman (Mr. Jasper), whereby Mr. Jasper agreed to supply and erect plant, works and machinery for the Company for the sum of £18,630, payable in 3,726 fully-paid shares of the Company, was discussed. As something had to be done towards starting the works (or the Provisional Order obtained by the Company would be revoked) and as the Company had been unsuccessful in borrowing the necessary money at 6 per cent. interest, the Chairman undertook the works himself and had actually spent £9.315. Some shareholders were disposed to think that Mr. Jasper was driving a hard bargain with the Company in claiming shares worth £18,630 in payment of the amount he had actually spent, but it was pointed out that the work was not finished, and that Mr. Jasper was still liable to pay a considerable additional sum. It was ultimately decided to adjourn the meeting for three months, and at the meeting last week considerable further discussion took place, and it was finally resolved to again adjourn for a week, three shareholders being appointed to confer with Mr. Jasper upon the subject. This conference has since been held, and to understand that arrangements satisfactory to all parties have been come to.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended June 25th were £765, as against £747 for the corresponding period of last year, being an increase of £18. The total receipts for the half-year amount to £21,799, against £20,132 in the corresponding period of 1892, being an increase of £1,667.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—Letters of allotment for the recent issue of 20,000 Preference shares in this Company have been posted.——The Directors of this Company yesterday declared an interim dividend of 3s. 4d. per £10 share, less income-tax, of the first issue of 20,000 Cumulative Six per Cent. Preference Shares Nos. 1 to 20,000 inclusive. The payment is calculated at the rate of 6 per cent. per annum on the respective instalments for the period ended June 30, 1893, and it is payable on July 11th next.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce that, subject to the final audit, the accounts show, after placing about £88.000 to reserve fund, a balance available sufficient to pay at the general meeting on July 13th next the fixed dividend of 3s. per share, being at the rate of 6 per cent. per annum on the Preference shares, less income-tax, and a final payment of 2s. 6d. per share with a bonus of 3s. per share, both free of income-tax, on the Ordinary shares, making, with previous payments on account, a total distribution of 6½ per cent. on those shares for the year ended March 31, 1893. The transfer books of the Company will be closed from July 6th to 13th, both days inclusive.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).—The Directors of this Company on Wednesday declared an interim dividend, for the quarter ended March 31st last, of 2s. 6d. per share, free of income-tax, payable on the 15th prox. The Share Register will be closed from the 7th to the 14th prox., both days inclusive.

GULCHER (NEW) ELECTRIC LIGHT AND POWER COMPANY (LTD).—An extraordinary general meeting of this Company will be held at Winchester House, E.C., on Monday, July 3rd, at three o'clock, "To receive and consider a report of the progress of the Company during the six months ended June 30, 1893; to appoint an auditor or auditors; and to consider the propriety of raising further capital."

JOHANNESBURG LIGHTING COMPANY (LIMITED).—A scheme for the reconstruction of this Company, with a capital of £155,000, is preparing. Ordinary shareholders will receive one share for two, 55.000 Ordinary shares will be exchanged for the 55.000 existing Preference shares and 60,000 shares will go to the subscribers of the £45,000 of working capital, which is needed.

REDRUTH ELECTRIC LIGHT COMPANY (LIMITED).—The Company which was to have been formed for supplying Redruth with the electric light has been abandoned owing to lack of public support. A considerable number of shares were applied for, but not enough to warrant going to allotment.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee appointed Wednesday, the 28th inst., a special settling day in the following:—Crompton and Co. (Limited), £50,000 Five per Cent. First Mortgage Debentures, Nos. 1 to 400 of £100 each, and Nos. A 1 to A 200 of £50 each. The Committee have ordered these debentures to be quoted in the Official List, as well as the following securities of the United Alkali

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Company (Limited):—289,343 Ordinary shares, Nos. 1 to 18,697 and 29,355 to 300,000; 282,524 Seven per Cent. Cumulative Preference shares, Nos. 1 to 122,195 and 139,672 to 300,000; £2,500,000 Five per Cent. Mortgage Debenture Stock.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended June 23, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,476.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 21.	Price Wednesday, June 28.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 28.	
						£ s. d.		Highest	Lowest.
			TELEGRAPHS						
£1,134,640	Stock	12/6	Anglo-American	51½ 52½	51 52	5 5 9	Jan., Apr., July, Oct.	51	..
£2,932,680	Stock	25/0	Do. Preferred	94½ 95½	94½ 95½	5 15 2	" "	95½	94½
£2,932,680	Stock	5/0	Do. Deferred	11½ 11¾	10½ 11	..	" "	11¼	10½
£195,100	100	4%	African Direct Telegraph 4% Deb. (Reg. & Bearer)	101 104	101 104	3 16 11	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	11¾ 12¼	12 12½	5 4 0	Mar., June, Oct., Dec.	12½	12¼
£36,400	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107 111	107 111	4 10 1	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	138 142	138 142	4 18 7	April and October..	..	..
16,000	10	8/0	Cuba Submarine	11½ 12½	11½ 12¼	6 8 0	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	18½ 19½	18½ 19¼	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½ 3½	2½ 3½	4 11 5	April and October...	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅞ 12⅛	11⅞ 12⅛	5 15 8	Jan., Apr., July, Oct.	12	11¾
400,000	10	2/6	Eastern	15 15½	15 15½	4 5 3	" "	15½	15
70,000	10	6%	Do. 6 per Cent. Preference	16½ 17½	16½ 17	3 10 7	" "	16½	..
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112 115	112 115	3 9 7	May and November	114½	113½
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	108 111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	15⅝ 15⅞	15¾ 16	4 7 6	Jan., Apr., July, Oct.	15⅞	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	113 116	113 116	3 9 0	February & August	114	..
£70 600	100	5%	Do. 5 p. c.(Austln. Gov. Sub.) Debs 1900	104 107	104 107	4 13 6	January and July ..	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb.,1900	103 106	103 106	4 14 4	" "	103¾	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	102 105	102 105	3 16 2	February & August	104½	104
£200,000	£25	..	Do. 4% Mauritius Sub. Debs. .....premium	3½ 4	3½ 4	..	May and November	..	..
180,227	10	2/3	Globe Telegraph and Trust	9⅜ 10	9⅜ 10	4 10 0	Jan., Apr., July, Oct.	10	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	15⅝ 15⅞	15⅝ 15⅞	3 15 7	" "	15⅞	15⅝
160,000	10	7/2	Great Northern	19½ 20½	19⅝ 20½	4 3 9	Jan., April, and July	20⅛	19⅝
£80,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105 108	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	39 42	39 42	5 19 1	May and November	41½	39½
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	6 13 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs.	101 104	101 104	3 16 11	..	..	..
11,802	8	4/0	Reuter's	5 6	5 6	..	April and October...	5⅛	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6 per Cent.	120 125	120 125	4 16 0	" "	..	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July ..	..	..
£260,930	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	3 4	3 4	..	January and July ..	..	..
£150,000	100	8%	Do. 8 per Cent. Debenturer, 1902	103 107	103 107	7 9 7	June and December	..	..
88,321	10	6d.	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 11½	10½ 11½	5 6 8	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9½ 10½	9½ 10¼	5 14 3	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	108 111	108 111	4 10 1	June and December	109	..
64,242	15	4/6	Western and Brazilian	7¼ 7⅜	7¼ 7⅜	4 13 11	May and November	..	..
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	5 15 3	..	6½	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1½ 2	1½ 2	..	..	1⅜	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106 109	106 109	5 10 1	February & August	..	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106 109	106 109	5 10 1	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120 125	120 125	5 12 0	May and November	..	..
£69,000	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	2 3	2 3	..	..	..	..
22,500	14/0	3½d.	Consolidated Telephone Const. & Maintenance	⅞ 1	⅞ 1	..	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	¼ ½	¼ ½	7 18 2	Yearly	..	..
458,867	5	2/6	National	5⅛ 5⅜	5⅛ 5⅜	5 11 7	June and December	5⅜	5⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14⅜ 15½	14⅜ 15½	3 18 8	" "	14⅞	14½
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14½ 14⅝	14½ 14⅝	4 1 4	" "	..	..
90,950	5	6⅜d.	Do. 5% Non-Cumulative 3rd Pref. (£3 paid)	5⅜ 5⅝	5⅜ 5⅝	..	..	5⅞	5⅛
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	113 117	113 117	3 16 11	January and July .	116⅛	115½
58,000	5	1/0	United River Plate	2½ 3	2½ 3	..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	11½ 12	11½ 12	..	—	..	..
20,000	10	..	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½ 12¾	12½ 12¾	..	..	12¾	12⅝
19,900	£5	..	Electricity Supply Co. for Spain	..	..	..	—	—	—
£150,000	£5	..	Electricity Supply Company Ordinary	5 5¼	..	..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	—	—	—
8,322	£5	..	House to House Electric	1½ 2½	..	..	—	—	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	5½ 5⅝	..	..	..	..	—
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	6 6½	..	..	January and July ..	..	—
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4⅞ 4⅞	4⅞ 4⅞	..	..	..	—
15,000	£5	5/0 '92	Do. (fully paid)	6⅝ 6⅝	6⅝ 6⅝	..	..	..	—
111,000	5	..	London Electric Supply	⅝ 1⅛	¾ 1¼	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6 6¼	6 6¼	3 1 6	..	6⅛	..
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102 105	102 105	4 15 3	June and December	..	..
6,452	£10	..	Notting Hill Electric	5 6	5 6	—	—	..	..
19,980	£5	9½%	St. James' and Pall Mall	7½ 7¾	7½ 7¾	..	—	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	8 8½	7¾ 8½	4 4 10	—	7¾	..
59,900	5	2/0	Westminster Electric Supply (fully paid)	5¼ 5½	5¼ 5½	3 0 10	—	5½	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/6	Brush Electrical Engineering	3 3½	3 3¼	..	—	3⅛	..
75,000	2	6%	Do. 6 per Cent. Preference	2½ 2⅝	2½ 2⅝	5 1 1	—	2⅝	2⅛
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107 109	107 109	4 2 7	March & September	109	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Cumulative Pref.	5¼ 5¾	5¼ 5¾	6 1 9	January and July ..	..	..
12,139	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	1⅜ 2¼	.. ..	..	—	..	..
49,900	10	12/0	Electric Construction	1⅜ 2¼	1⅜ 2	..	—	2¼	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜ ⅝	⅜ ⅝	..	—	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	—	..	..
50,000	10	15/0	India Rubber, Gutta Percha &c., Works	22½ 23½	22½ 23½	5 6 4	February & August	23½	23½
£20,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	2½ 3½	2½ 3½	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	5/0 6/0	5/0 6/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	2 2½	2 2½	14 11 6	May and November	2⅜	2½
37,350	12	24/0	Telegraph Construction and Maintenance	33 35	34 36	5 0 0	March and July.....	35	34
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106	103 106	4 14 4	January and July .	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	—	—	—	—
41,038	£5	..	Do. Preference (fully paid)	.. ..	.. ..	—	—	—	—
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	4%	City and South London Railway	87 89	86 88	1 12 10	May and November	..	..
37,500	£10	£10	Liverpool Overhead Railway	5⅜ 5⅝	4½ 4¾	—	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 790.—Vol. XXXI. FRIDAY, JULY 7, 1893. PRICE FOURPENCE. *Annual Subscription (U.K.), 19/6*

NOTES.

Our readers will remember that an attempt was made some ime ago to establish telegraphic communication between undy Island and the mainland at Hartland point. On this sland there has been for many years an important lighthouse, vhich protects vessels entering the Bristol Channel. A cable was aid in March, 1884, by a small company; and was partly sup-orted by a subsidy of £100 a year from Lloyd's, who under-ook to place a signal station on the island, and partly by a oyalty of two shillings which was levied on each message ransmitted to the mainland. But the apathy of the sailor, vho generally did not care to spend money on signals when nly a few hours' run from port, and the physical evils of a wift tideway and a rocky sea-bottom, soon threw both cable nd company out of working order. The latter was wound p, and the former was hauled up, and sold to Mr. Rogers, vho had undertaken the laying of it. A new cable has ecently been laid, and we learn on inquiry that the work as been done in connection with the extensive Government cheme of coast communication; and that the new cable has een laid between Lundy and Braunton, a point some distance ıside the Barnstaple Bay, whereby it is less exposed to the ffects of rocks and the tidal wash.

There is a general impression that on November 11th next, wing to the expiry of Edison's patent No. 4,576, on the 10th, ne English market will be open for the sale of glow lamps. o what extent certain subsequent patents for details of onstruction or for lampholder fittings can be avoided, remains o be seen; but these matters have doubtless received the areful attention of importers. The subject of the manufac-ure of glow lamps has been devoid of all interest to English lectricians for many years, seeing that even experimental work s prohibited under the Patent law, and the number of nen outside the Ponder's End factory who know anything bout it is very limited. Of these few Mr. Gilbert S. Ram is ne who has had considerable practical experience both in the nited States and in this country; and this week we begin a eries of articles which form part of a book on "The Incan-lescent Lamp: its Manufacture and Use." As this book vill shortly be published we shall be unable to print any con-iderable portion of it in full in our columns, as was done with Prof. Ewing's "Magnetic Induction in Iron and other Metals," or Prof. Fleming's "Alternate Current Transformer," but selections will be made with the view of giving a general idea of the processes of manufacture and the principles which underlie them.

Electrical research should receive a healthy stimulus, and scientific progress ought to be accelerated to some extent, by the complete set of laboratories which has recently been built under the auspices of the Société International des Electriciens in Paris, and which was recently opened by M. Terrier, the Minister of Commerce and the Colonies. The institution includes ten laboratories and a dynamo room, in the latter of which there are a gas engine and triple expansion steam engine. The equipment of the laboratories seems to be very perfect, and the ten rooms are devoted severally to wire testing, cable testing, calibrating voltmeters, measurements of potential, electro-chemistry, calibration of ammeters, photometry, measurements of capacity, standardising resistance coils, besides an accumulator room containing various types of cells. The entire *ensemble* of the institution affords an additional instance to the many we already have of the thoroughness and vigour with which technical progress is pushed forward in France and other continental countries.

The representation of abstract truth and of theory in science, by the aid of diagrams and models, is one which is helpful alike to investigators, teachers, and scholars. In another column we publish an interesting abstract from the catalogue of the Mathematical Exhibition, in which Prof. Boltzmann attaches prime importance to Maxwell's models in the deduction of the Maxwell theory of electromagnetism. In this we, however, cannot entirely agree; for it can never be true that the amount of concrete truth contained in a model can be greater than the amount of pure or abstract truth which was put into it in its original conception. A model, in so far as it is such and nothing else, is merely a tangible presentiment of one or more ideas in the mind of the person who designs it. Hertz's praise was rightly bestowed, not because the models contained more than the equations they represented, but because Nature is always deeper than our profoundest conception of her, and because the closer the equations are to natural truth the more they must reflect the deeper truths of Nature.

To apply the elaborate algebra, which Mr. Rimington contributes this week, to the unpretentious little cell-testing device of Major Holden is to break a butterfly upon the wheel. The instrument was not submitted to us as an apparatus for

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measuring the internal resistance of a battery, and we were careful, both in the title and in the first sentence of our article on it a fortnight ago, to suggest that it was suitable for testing the condition of a cell rather than for making an accurate scientific determination of a quantity, which is, after all, purely hypothetical. Given a cell, which, admittedly, polarises when it is discharged; to make an examination which eliminates polarisation, is to make an examination in which practical considerations are ignored. "Why, you must have been taking it out in the rain and getting it wet!" said the shopkeeper, in *Punch*, to the disgusted purchaser of an umbrella.

It is often necessary to draw a hard line between scientific and practical modes of work or thought. This question of internal resistance of batteries is a good example. A knowledge of the internal resistance of a battery is only of importance to most users of batteries, when it is accompanied by a statement of the relation between the resistance and the current given by the cell. This relation nobody seems to trouble themselves about, partly, perhaps, because a third factor, the condition or age of the cell, must be taken into account. In theoretical investigations of electro-chemical action and of electromotive force, as distinguished from difference of potential, true internal resistance must be accurately measured, although it is a quantity which really exists only as a limit. We, therefore, welcome Mr. Rimington's contribution to this subject. His criticism of the accuracy of the Holden cell tester requires a word of comment. It is true that an error of one per cent. in a reading produces large errors in the result, but a delay of a second or so will produce quite as large an error with most primary batteries, due to a change, not only in the readings, but in the quantity to be measured. In checking Mr. Rimington's comment on the readings of the E.C.C. cell, we find there is a misprint in the second reading on page 200, and, on examining the original diagram sent by Major Holden, the real value seems to be about 1·36.

We have tried the Holden cell tester on a few different cells, and find it to be very easy to use. After a little practice it would not be difficult to form an opinion of the condition of a cell from a mere glance at the two positions of the needle without having recourse to either diagrams or calculations. The cells we tested were all old, and are used for lighting a lady's house in Kensington. A large "Law" Leclanché had an internal resistance of 0·51 ohm, a small "Henry" dry cell 0·55 ohm, and a small Hellesen cell 0·54 ohm. It should be observed that while the load on these cells is severe while it lasts, they are not used every evening; the lady is about four years old, and the house is a doll's house.

Standard Wave-Lengths.—The results of ten years' research on wave-lengths, which has been made by Prof. Rowland and Mr. Jewell, are now published in the form of a comprehensive table in the July number of the *Philosophical Magazine*.

Personal.—Mr. J. T. Sheldrick, who was for many years in charge of Messrs. Easton and Anderson's drawing office, has taken offices at Mansion House-chambers, 11, Queen Victoria-street, E.C., where he is practising as consulting engineer.

Cable Interruptions—	Interrupted.
Paramaribo—Cayenne	April 15th.
St. Thome—Loanda	May 30th.

Melbourne.—The inhabitants of this city have been promised by the City Council that one half of the city shall be illuminated with the electric light in six months, and that within 12 months electricity will entirely supersede gas for street lighting.

Royal Institution.—At the last general monthly meeting further donations to the fund for the Promotion of Experimental Research at Low Temperatures were announced. Mr. Ludwig Mond contributed £500, Mr. Robert Hannah £50, besides three other donations of £21 each.

The Mathematical Exhibition.—This exhibition of models and other works of interest connected with abstract and theoretical science, which it was originally intended to hold at Nuremburg last year, will be held at Munich next September. The Exhibition is under the auspices of the Association of German Mathematicians.

Buda-Pesth Electric Tramways Company.—This Company carried in 1892 14,000,000 passengers as against 8,500,000 in 1891; receipts increased nearly 50 per cent., and stand at 766,000 florins; a dividend of 7 per cent. was paid, and 28,000 florins placed to reserve. The remaining capital is to be issued at 150, or 50 per cent. premium.

The Value of H.—The new unifilar magnetometer, at the Kew magnetic Observatory, has during the past year been compared with the older instrument. The mean of the monthly values of the horizontal component of the earth's magnetic field made with this instrument is 0·18288, which is 0·0023 greater than the mean given by the old instrument.

City and Guilds of London Institute.—The Matriculation Examination of this Institution will be held on September 19-22nd next; and the Entrance Examination to Finsbury College on the 29th of that month. Particulars of these examinations, and of the courses of lectures and practical instruction will be found in our advertisement columns.

Glasgow and West of Scotland Technical College.—Henceforth Prof. Jamieson will devote his attention exclusively to electrical engineering. The subject of mechanical engineering is to be taught by a new professor, whose chair is to be that of "Steam, Steam Engines, and other Prime Movers." For the chair there were 24 applicants, of whom Mr. W. H. Watkinson has been selected.

Meteorology in Wales.—Sir Edwin Watkin has placed a telephonic wire between the summit of Snowdon and the Post Office at the vale of Gwynant, on the picturesque slope of which the chalet stands. The service was opened on the 6th inst. in celebration of the Royal wedding. Daily reports of the state of the weather on Snowdon will be furnished to the Meteorological Department.

Lightning.—A heavy thunderstorm at Leeds during the past week completely interrupted the telephone service. Near Leicester a man was killed by a lightning flash; but, quite the reverse of what usually happens, his watch was not stopped. The man's clothing was saturated with rain, which may account for the safety of the timepiece. At Gainsboro' a telephone pole was shattered.

Electricity in Mining.—At the last meeting of the Mining Association of Ecos, the Director of Collieries at Logamba (Mr. Weir) described an electric transmission plant for working the pumps and hauling machinery at the mines. The output of the generator is 200 amperes at 2,000 volts, and an electric motor of equal power, placed at the pit's mouth, works the machinery. The operation of the electric plant gives great satisfaction.

International Electrical Congress at Chicago.—Prof. H. S. Carhart, Honorary Secretary of the Chicago World's Congress of Electricians, informs us that the following have promised to read Papers at the Congress:—Mr. W. H. Preece—"Signalling Through Space by Means of Electro-Magnetic Vibrations;" Prof. W. E. Ayrton—"The Variation of P. D. of the Electric Arc with Current, Thickness of Carbons, and Distance Apart."

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Lightning Protectors in Powder Magazines.—A series of articles on the protection of magazines and explosives factories from lightning, is now appearing in our contemporary, *Arms and Explosives*. In the current number a "cheap earth," invented by Dr. Mann, is one of the various useful things described. This "earth" is composed of lengths of stranded cable, with the strands frayed out and led, like a fibrous root, in all directions into the soil.

Hutin and Leblanc Alternate-Current Motor.—We believe that the very latest type of motor which has been invented by these engineers may be adapted to ordinary alternate-current mains, without the use of condensers. It is claimed that this machine possesses all the good qualities of a continuous-current motor, the effects of self-induction having been prevented by the use of graduated brushes coupled to non-inductive resistances, combined with a form of armature winding of the Pacinotti-Gramme type.

Electric Light Plants in Switzerland.—In the *Annuaire de l'Association Suisse des Electriciens* for the current year we note a list of the Swiss electric light and power installations of more than 100 16 c.p. lamps or their equivalent. From this table it appears that there are 94 installations in textile factories, 42 in engineering shops, 12 in paper or chemical works, and only one in a printing office. Central stations number 37 and power transmissions 56. Some 13 breweries, 5 railway stations, 5 streets, 76 hotels, and 33 miscellaneous buildings also possess electric light plants.

Obituary.—We are informed of the death of M. Daniel Colladon, of Geneva. Students of physics who have read the older text-books on the subject will remember that M. Colladon, in conjunction with M. Sturm, determined the velocity of sound in water by experiments made on the Lake of Geneva. M. Colladon first lit Geneva with gas in 1843, and was connected with the illumination of other towns by the same agency. He was strongly prejudiced against the electric light, and went so far as to resign his membership of a Geneva club because it was decided to use the electric light.

Conversazione.—More than a year ago we ventured to suggest that as nobody at that time seemed to have a clear idea of what was going to be done at the Imperial Institute, it might be used with great advantage for the *conversazioni* of scientific and other societies. An exceptionally agreeable *conversazione* of the Society of Arts was held at this Institute on Friday last. The gardens were illuminated with oil and gas lamps, and the galleries and hall with electric lights. The opinion was expressed that the use of arc lamps in the gardens would have spoiled the effect of the coloured lights.

Lamp-Circuit Interrupter.—M. Félix Leconte has invented a form of automatic mercury switch, which, when combined with a clock, enables any lamp-circuit to be opened and the lamps extinguished at any desired time. The clock is arranged so as to close a relay circuit, containing an electromagnet, at the prearranged time, and the pull of this magnet is exerted upon a disc of iron which is normally held by springs against a hole in the bottom of the mercury cup. As the mercury forms part of the lamp-circuit, and carries the whole current, the momentary pull of the electromagnet will break the circuit by opening the hole in the cup and allowing the mercury to flow out.

Rapid Transit.—Notwithstanding the recent collapse of certain rapid transit schemes in America, which promised great things at the beginning, there is to be an attempt, we hear, to solve the problem on an experimental line which is about to be erected on Long Island. The wheels of the carriages are to be arranged bicycle-fashion upon a single rail, and a guiding rail will be placed above the carriages. Each carriage is about 60ft. long, and weighs about 3·5 tons. The line is a little more than a mile and a-half in length, and a speed of 100 miles an hour is expected to be attained. About 75 H.P. is to be supplied for this performance, and at full speed the motor armature will make 560 revolutions per minute.

Municipal Amenities.—As the clocks were striking the hour of midnight on the night of May 28th a small army of 400 men armed with picks, shovels and other tools, marched forth from the power house of the Omnibus Cable Company of San Francisco. In less than an hour 10 sets of side poles for electric railway wires were firmly planted in cement, and material was on hand to occupy a hundred more holes which by this time appeared along the curbs. The superintendent of police, however, discovered them, and going to the Mayor secured sufficient police force to stop work. The Company were relying on securing an injunction restraining the city from removing the poles, but the mayor anticipated this and with another large force pulled them all up before breakfast.

Electrically-Controlled Clocks on Lighting Mains.—The Allgemeine Elektricitäts-Gesellschaft send us a note describing an invention of Herr von Hefner-Alteneck, for utilising the central stations in connection with electrically-controlled clocks, on the advantage of which they lay some stress. The invention consists in a clock so arranged that it can be coupled to the lighting mains, and is periodically wound up by electrical means; and that further, once a day, the clock is put right by means of a small and momentary diminution of pressure on the mains, about 6 to 10 volts; this being done at an hour when few lamps are on. It is necessary to keep the pressure right just before the clocks are set daily, but variations at other times do not affect the working. The setting can be done automatically by a standard clock, or by hand, and is said to cost about 4d. per year.

"Drehstrom" Circuit.—Messrs. Siemens and Halske send us some information with regard to a new "drehstrom" transmission of power on which they are engaged, by means of which it is proposed to supply the towns of Elgoibar and Eibar, in the province of Viscaya, in Spain, with electrical energy for lighting and power, derived from the river Deva. A weir has been constructed, by which a fall of 26ft. is obtained, the amount of water coming over being sufficient to supply 300 H.P. The plant is of the usual type, and calls for little notice. The dynamo runs at 120 volts, and the pressure is transformed up to 5,000 volts in the conductors, which transmit the energy to distances of one and three miles to the two small towns. The energy at Eibar is chiefly used for the arms factories, of which several exist here. The undertaking is a private one, and has been started by the owner of the water power.

Scarborough.—A prominent feature of the new electric light works is a chimney of large proportions, about 200ft. high. It is built upon a solid block of concrete, upon a bed of clay. When nearly the maximum height it was found that a settling had occurred in the crown of the arch of the flue. This did not amount, at the point at which it occurred, to more than 2in., though it threw the shaft out of the plumb some 18in. at the top. Work was at once stopped in the structure, and experts were called in to give their advice. They reported that the chimney could be straightened by cutting the courses on the side opposite to that on which the settlement occurred. The Directors of the Company met to consider the report of the experts, and it was stated that in most cases of falls of chimney shafts, the courses had previously been cut in order to straighten them. It was felt that it would be better to run no risks, and it was ultimately decided to pull the chimney partly down and rebuild it again.

The Visible Representation of Lines of Electric Force.—The following experiment for making visible lines of electric force is described by Herr Bruno Kolbe:—Into a flat cylindrical vessel pour purified anhydrous oil of turpentine to a depth of about 2cm., and add some sulphate of quinine. To the rim of the vessel attach two wire springs, adjusted so that the two small metallic balls at their ends dip into the turpentine. Stir the quinine with a glass rod so as to distribute it evenly, and place the vessel on a black cardboard. Join the two wires to the terminals of an influence machine, and turn very slowly. At once the white crystals group themselves so as to form beautiful curves, representing the "lines of electric force." The form of these curves recalls that of the brush discharge of the influence machine. Prof. Weiler, of Esslingen, gives the following experiment:—Prepare a milky mixture by stirring up finely-divided quinine in oil of turpentine. On sending a series of discharges through it a clearance is produced at the positive pole, and the particles cluster round the negative pole, arranging themselves in streamers directed along the lines of

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force. The phenomenon is analogous to that of electro-deposition. A piece of sheet metal, bent into a cylinder and immersed vertically into the liquid, behaves just like a piece of iron in a magnetic field, creating a new positive and negative pole.

The Methods of Theoretical Physics.—A translation of an important Paper by Boltzmann, upon this subject, appears in the July number of the *Philosophical Magazine*. The Paper originally formed an introduction to the Catalogue of the Mathematical Exhibition, which has been postponed till next September, and deals with the relation of graphic and model represention to physical hypotheses and theory. We quote the following from the section on electricity :—

"In his (Maxwell's) second Paper he goes still further, and from liquid vortices, and friction wheels working within cells with elastic sides, he constructs a wonderful mechanism, which serves as a mechanical model for electromagnetism. This mechanism was mocked at by those who regarded it as a hypothesis in the older sense of the word, and who thought that Maxwell ascribed to it a real existence. This he repudiates, and only modestly hopes '*that by such mechanical fictions anyone who understands the provisional and temporary character of this hypothesis will find himself rather helped than hindered by it in his search after the true interpretation of the phenomena.*' And they were so helped ; for by his model Maxwell arrived at those equations whose peculiar, almost magical, power Hertz, the person most competent of all to judge, thus vigorously depicts in his lecture on the relations between light and electricity : 'We cannot study this wonderful theory without at times feeling as if an independent life and a reason of its own dwelt in these mathematical formulæ ; as if they were wiser than we were, wiser even than their discoverer ; as if they gave out more than had been put into them.' I should like to add to these words of Hertz only this : that Maxwell's formulæ are simple consequences from his mechanical models ; and Hertz's enthusiastic praise is due in the first place, not to Maxwell's analysis, but to his acute penetration in the discovery of mechanical analogies."

An Electro-Chemical Actinometer.—In communications to the *Annales de Chimie et de Physique* and to the *Comptes Rendus*, M. Rigollot has shown that it is possible to make a very sensitive electro-chemical actinometer by employing an electrode of oxide of copper in a chloride, bromide or iodide solution. The electromotive force caused by allowing light rays to fall upon the oxidised electrode may be considerably augmented by giving the oxide a thin film of some colouring substance, such as eosin, erythiosin, sofranine, green malachite, poppy, green crystals, formyl violet, soluble blue, &c., &c. After the plates have been dipped in the colouring matter they may be washed and dried, and even rubbed with filter paper, without losing their augmented sensitiveness. The increase in electromotive force depends, in the case of white light, upon the colouring substance employed. Using an oxidised copper strip 0·3cm. broad by 1cm. long, and a 1 per cent. solution of iodide of sodium, the following results were obtained by causing rays from different parts of the spectrum to fall in succession upon the electrode both before and after immersion in crystal green :—

		λ = 684	650	600	550	500	450	410
Non-sensitised	Scale of divisions.	16	18	80	190	203	200	88
Sensitised		140	760	600	408	380	288	168

It will be seen that the most active rays are those which lie in the part of the spectrum where the absorption band of the colouring solution is found.

Indiarubber Tests.—Lieut. L. Vladimiroff has recently carried out a series of tests at the St. Petersburg Technical Institute with a view to establishing some rules for judging the quantity of vulcanised indiarubber. Most of the tests were of a physical nature. The following, according to the *Indiarubber, Guttapercha, and Electrical Trades' Journal*, were the conclusions arrived at—namely : 1. Indiarubber should not give the least sign of superficial cracking when bent to an angle of 180 degrees after five hours of exposure in a closed air bath to a temperature of 125°C. The test pieces should be 6cm. thick. 2. Rubber that does not contain more than halfit weight of metallic oxides should stretch to five times its length without breaking. 3. Caoutchouc, free from all common matter, except the sulphur used in vulcanising it, should stretch at least seven times its length before rupture. 4. The extension measured immediately after rupture has taken place should not exceed 12 per cent. of the original length of the test piece of rubber. The test piece should be from 3mm. to 12mm. long, 3cm. wide, and not more than 6mm. thick. 5. Softness may be determined by measuring the percentage of ash formed on incineration ; it may form the basis for deciding between different grades of rubber for certain purposes. 6. The vulcanised rubber should not harden under the influence of cold temperature. These conditions are to serve in the establishment of rules governing the introduction of vulcanised rubber into the Russian Navy.

The Utilisation of Small Waterfalls.—In a recent number of *La Lumière Electrique*, M. Chédeville devotes several columns to a discussion of how to make the best use of small waterfalls, a subject which is of some interest in this country. He dismisses accumulators as out of the question, and merely mentions the Geneva plan of using low-pressure turbines to pump water, during the twenty-four hours, into a high-pressure reservoir. M. Chédeville's specific is the erection of dams, which he thinks is much more generally possible than is usually imagined. The article concludes with an instructive concrete example. The stream to be utilised is a tributary of the Marne, and the village to be lighted is about half-a-mile away from a 33ft. fall. Careful measurements of the flow, extending over a twelvemonth, and including two periods of exceptional drought, show that the average flow is 49½ gallons per second, the maximum being 286 and the minimum 7¾ gallons per second. During the winter, a minimum of 17½ gallons per second may be counted on, which, allowing for turbine, dynamo, line, and other losses, would leave only some 5¾ H.P. available, or just about enough power to light 150 8-c.p. lamps. The stream happens, however, to run through a narrow valley with steep sides, and containing nothing but barren land, and by running a dam about 60 yards long across the outlet, a natural reservoir, having a capacity of 396 million gallons could be obtained, with a fall, when the reservoir was full, of about 70ft. This would enable the average winter flow of 66 gallons to be made use of, for the six hours of lighting only, at the rate of 264 gallons per second, which, with an average head of 53ft., and allowing for the usual losses, would leave 156 H.P. available, and enable several thousand 8-c.p. lamps to be alight simultaneously.

Telephone Disturbances at Marseilles.—Some unpleasant disturbance of the telephone circuits formerly took place in the neighbourhood of the electric tramway at Marseilles. Weird noises, from a low rumble to a piercing shriek, resembling, it is said, a syren (not the luring syren of Scylla, but the fog-horn of that name), were constantly heard in the telephones, and human speech had little chance of transmission. The civil authorities, interposing in the interest of the telephone, stopped the running of the electric cars. But this solution of the difficulty, savouring, as it did, more of autocratic power than of sweet reasonableness, could only serve as a temporary measure. Now, both the telephone circuits and the traction lines were, at that time, working on the single-wire system. The traction current was carried along the rails and returned by the overhead trolly wire. Leakage to earth occurred, of course, pretty freely. The telephones were worked on the earth-return system, with a single line connecting each instrument to the central office. Disturbances were the natural result of the proximity of two such systems. Ultimately the difficulties were overcome in what would appear to be the most reasonable manner, for the telephone proprietors were ordered to remove those portions of their lines which were immediately under the disturbing influence, and to replace these by poles capable of carrying wires at a sufficient height to be free from induction, the wires being duplicated so as to form a completely insulated metallic circuit for the telephone current wherever any such disturbance might be feared. Since the telephone lines have been doubled the disturbances arising from the proximity of the tramway system have been found to be negligible and incapable of interfering with the transmission of speech. While commenting on the effect of the Marseilles traction system, we may refer to the somewhat remarkable, and probably unique, system of earthing the positive pole and taking the current back through the trolly wire. This is a reversal of the usual practice, but it would, of course, make no difference to the disturbances caused by earth currents. The purpose in view in adopting this arrangement is the prevention of electrolytic action causing an increase in the line resistance.

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ELECTROMAGNETIC THEORY.—LII.

BY OLIVER HEAVISIDE.

(Continued from page 145.)

§ 204. By replacing fictitious magnetic conductance of the medium outside the pair of leads by real electric resistance of the leads themselves, we have obtained the same results as regards the propagation of waves, subject to certain reservations referring to the practical applicability of the theory. It is worth while noticing, in passing, a certain peculiarity showing roughly when we may expect the theory to be admissible, and when it should fail. We know that in the transmission of waves along perfectly conductive leads the waves are continuously distorted if the medium be electrically conductive. Also, that by introducing magnetic conductivity into the medium we may reduce this distortion, and ultimately abolish it when the magnetic conductivity reaches a certain value. Now observe here that the correcting influence of the magnetic conductivity is exerted precisely where it is required, namely, in the body of the wave itself. The wave is acted upon in every part by two counteracting distorting influences, so that the correction is performed exactly; in other words, we obtain an exact theory of distortionless transmission.

But, on the other hand, when we employ the resistance of the leads to perform the same functions, the correcting influence is not exerted uniformly throughout the body of the wave, but outside the wave altogether; at its lateral boundaries, in fact. Nevertheless, for reasons before stated, we still treat the waves as if they preserved their planarity under the influence of the resisting leads. Whilst, therefore, we fully recognise and employ the finite speed of propagation of disturbances axially, or parallel to the leads, we virtually assume that the correcting influence of the leads is transmitted laterally outwards instantaneously. We may, therefore, perceive that the wave-length is a matter of importance in determining the applicability of the practical theory. It is of no moment whatever in the exact theory employing magnetic conductance; but, when we remove this property from the medium generally, and (virtually) concentrate it at the leads, we should at the same time keep the wave-length a considerable multiple of the distance between the leads if the practical theory is to be applicable. To see this, it is sufficient to imagine the case of waves whose length is only a small fraction of the distance between the leads, when it is clear that their correcting influence could no longer be assumed to be exerted laterally and instantaneously, as if the small portion of the leads between two close reference planes belonged to and was associated solely with the slice of the medium between the same planes.

We have referred in the above to the action of the resistance of the leads as a correcting one, neutralising the distortion due to another cause. But the same reasoning is applicable when the action is not of this nature. Thus, when the external medium is non-conductive, and the leads are non-resistive, we have perfect transmission. Making the leads resistive therefore now brings on distortion. We may now say that in order that this distortion should occur in the same way as under the influence of magnetic conductivity in the external medium, the wave-length should not be too small, as specified above. The practical theory is therefore the theory of long waves, and in the interpretation of the word "long," some judgment may be exercised as regards the leads and other matters, because there is no hard and fast distinction, and what may be a long wave under some circumstances may be a short one under others.

To illustrate this point, imagine that we have got an ingenious instrument (not yet made), for continuously recording the electromagnetic state of a non-conducting medium, say the air at a certain place (just as we have thermometric and barometric recorders), and that this instrument is so immensely quick in its action as to take cognisance of changes happening in very short intervals of time, say one thousand-millionth of a second. Now in applying this instrument to register the state of air traversed by electromagnetic waves, it is clear that the size of the waves must be considered in relation to the size of the instrument. If the instrument were one decimetre across, then waves of one kilometre in length could as well be regarded as of infinite length. But if only one metre in length, though it could still be used, there would be no longer the same accuracy of application. And if of only a centimetre in length, then it is plain that several waves would be acting at once on the apparatus in different parts, and the resultant effect recorded would not represent the history of the waves by any means.

Now as regards waves sent along parallel leads, it is obvious that light waves are totally out of the question, being immensely too short. On the other hand, telephonic waves are to be treated as long waves—very long, in fact—though they are short compared with telegraphic waves. But it is somewhat curious that the electromagnetic waves investigated by Hertz are sometimes so short as to come within the scope of the above reservational remarks, or of others of a similar nature. Whether the generation of waves by an oscillator be considered, or their effect on a resonator, or their transmission along leads, their shortness in relation to the apparatus employed may sometimes vitiate the results of approximate theories, and render caution necessary. For example, the plane-wave theory indicates that the attenuation factor for waves running along parallel leads is $\epsilon^{-Rx/2Lv}$ in the distance x, or $\epsilon^{-Rt/2L}$ in the equivalent time of transit t. This is when R and L are constants. If not, and the waves be simply periodic, then we may use the same formula with the effective values of R and L at the frequency concerned. But if this be true for long waves, we cannot expect it to continue true on shortening the waves to the transverse distance of the leads, more especially if we are ignorant of the precise type of the waves. At the best, we should not expect more than results of a similar kind. But not much has been done yet in the quantitative examination of Hertzian waves, for sufficiently obvious reasons.

In one respect, however, a formerly very strange anomaly has been cleared up satisfactorily. When Hertz opened people's eyes and made them see the reality of Maxwell's ether as a medium propagating electromagnetic disturbances at the speed of light, by showing their transmission across a room and reflection at a wall, the full acceptation of Maxwell's theory was considerably hindered for a time by his finding that the speed of waves sent along wires was much less than that of free waves. The discrepancy was a large one, and gave support apparently to the old view regarding the function of wires, which made the wires the primary seat of transmission, and effects outside secondary, due to the wires. And it came to pass that people, whilst admitting the truth of Maxwell's theory, yet made a distinction between waves in free space and "in wires." This was thoroughly out of harmony with Maxwell's theory, which makes out that the wires, though of great importance as guides, are nevertheless only secondary. On the other hand, it should be mentioned that Lodge found no such large departure from the speed of light in his experiments. But the matter has been explained by the discovery that an erroneous estimate was made of the permittance of the oscillator in the experiments, which apparently showed that the speed was largely reduced. When corrected, there is not left any notable difference between the speed of a free wave and of one guided by wires. Of course, there is no reason why reference to waves "in wires" should not be dropped, unless the laterally-propagated cylindrical wires are meant. These are secondary, and have no essential connection with the propagation of the primary waves through the external dielectric, although modifying their nature.

§ 205. When waves are left to themselves in ether without the presence of conductors, they expand and dissipate themselves. Even if they are initially so constituted as to converge to centres or axes, they will subsequently expand and dissipate. To prevent this we require conducting guides or leads. Now this usually involves dissipation in the leads; but the point at present under notice is the property of guidance only. We can stop the expansion in a great measure, and cause a wave to travel along wherever we wish it to go. Practically there are two leads, as a pair of parallel wires; or if but one wire be used, there is the earth, or something equivalent, to make another. But it is still much the same, as regards guidance,

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when there is but one wire, if we choose to imagine the case of a single infinitely-long straight wire alone by itself in ether. If we make it the core of a plane electromagnetic sheet, this sheet will run along the wire just as well and in the same way as if there were a second guide. But the energy of such a sheet, even though of finite depth, and containing electric and magnetic forces of finite intensity, would be infinite. The quantity L, the inductance per unit length of guide, is infinite under the circumstances. We could not, therefore, set up such a wave from a finite local source. If we cause an impressed voltage to act axially for a very short interval of time across any section of the guide, say in a reference plane, the result is an approximately spherical wave. (To be perfectly spherical, the wire should be infinitely fine. The case is then that of a spherical wave-sheet with conical boundaries, already referred to, with the angle of the cone made infinitely small.) Its centre is at the origin of the wave, and as it expands, the portions of the wave-sheet nearest the wire become approximately parallel plane waves, one going to the right, the other to the left along the wire. But not being pure plane waves they are weakened as they progress, by the continuous expansion of the spherical wave of which they form a part. Nevertheless, we have the propagation of nearly plane waves of finite energy, or of a perfectly plane wave-sheet of infinite energy, along a single guide.

Now, this takes place outside the conducting guide, and the question presents itself whether we cannot transmit an electromagnetic wave along the interior of a tube, in a manner resembling a beam of light? We can certainly do so if we have a second guide within the first tubular one, for this does not differ substantially from the case of two parallel wires, each outside the other. But it does not seem possible to do without the inner conductor, for when it is taken away we have nothing left upon which the tubes of displacement can terminate internally, and along which they can run. A theoretical expedient is to carry the electrification forward at the proper speed. But we want the process to be automatic, so to speak, hence convection will not do. Again, if we make the displacement start from one portion of an electrically conducting tube and terminate upon the rest, we must insulate the two portions from one another, and then there will be a division of the charges between the interior and exterior, so that the result will be an external as well as an internal wave, or rather, one wave occupying both regions.

It would appear that the only way of completely solving the problem of the automatic transmission of plane waves within a single tube is a theoretical one, employing magnetic as well as electric conductance. To see this, imagine any kind of purely plane wave being transmitted in the normal manner through the ether, and fix attention upon a tube of the flux of energy, or a beam, using optical language. This beam cuts perpendicularly through the reference planes, in which the lines of electric and magnetic force lie, which again cross one another perpendicularly. The shape of the section of the beam by a reference plane may be arbitrary. But let it be quadrilateral, and so that it is bounded by magnetic lines on two opposite sides, and by electric lines on the other two. Now let the two sides of the tube upon which the displacement terminates perpendicularly, be electrically conducting thin sheets, and the other two sides, upon which the induction terminates perpendicularly, be magnetically conducting sheets. If the conduction be perfect, we shall not interfere with the transmission of the beam within the tube. That is, we have solved the problem stated. We may also notice that the external portion of the wave is not interfered with by the tube. But the interposition of the tube in the manner described renders the external and internal waves quite independent of one another, and either of them may be suppressed.

Similarly, if the interior region be made finitely conductive, electrically or magnetically, or both together, we can still investigate the transmission of waves along it in the same way as previously described for complete plane waves in a homogeneous medium made conductive, and the same applies to the external region, independently of the internal. Going further, we may do away with the diffused conductance, and concentrate equivalent resistances in the plates bounding the tubes, in the same way as we replace magnetic conductance of the external medium by equivalent electric resistance of the wires in passing from the exact plane-wave theory to the practical theory of wires in terms of V and C. That is, the two plates on which the displacement ends may be made electrically resistive, the resistance taking the place of the magnetic conductance in the interior; whilst the other two plates should be made magnetically resistive, if the interior electric conductance is also to be abolished. We may then express the propagation of waves in the tube in a manner resembling the practical theory of wires, though it will no longer be an exact theory. Nor will the interior and exterior regions be quite independent of one another now that the tube is only finitely conductive.

§ 206. Leaving these somewhat abstruse considerations, return to the practical theory concerning wires and its connection with the exact theory involving magnetic conductance. In the working out of the practical theory (which is not yet, however, the theory of official representatives of practice, though they are decidedly getting on) we have often to consider the effects due to intermediate insertions of resistance in the circuit of the leads, or of shunts across them, and other modifications. The question now is, what do these insertions represent in the exact theory?

Consider first a pair of parallel leads of no resistance. This will admit of the application of the exact theory, provided there be either no leakage or the external medium be uniformly conductive electrically. Now we know that when the leads have resistance, we make the transformation to the exact theory by substituting uniform magnetic conductivity of the external medium of the proper amount. Plainly, then, if we insert an electrical resistance in a lump in the circuit of the leads at any place, we should, in the exact theory, transfer it equivalently (changed to magnetic conductance) to the whole of the corresponding reference plane. That is to say, we must make the reference plane (outside the leads) uniformly conductive magnetically, so that the total magnetic conductance of the equivalent plate inserted equals the electric resistance which it replaces. We may then investigate the action of the plate on the waves traversing it in the manner described in a previous paragraph.

Similarly, the effect of an electrically conducting bridge across the circuit is equivalent to that of an electrically conducting plate at the reference plane. Their conductances are here not only equal, but of the same kind. We merely rearrange the leakage conductance so that it shall act uniformly, to suit plane waves.

Thus, a terminal short-circuit should be replaced by a terminal perfectly conductive plate, reflecting **H** positively and **E** negatively, or with reversal of sign; or, which is the same, C positively and V negatively. This maintains **E** and V permanently zero at the short-circuit, unless there be impressed force there. And a terminal disconnection may be represented, in the exact theory, by a terminal perfectly magnetically conductive plate, reflecting **E** positively and **H** negatively, or V positively and C negatively, thus maintaining C permanently zero at the disconnection.

A somewhat different kind of transformation is required in connection with impressed forces. Suppose, for instance, we insert an impressed voltage in the circuit of the leads at a given reference plane. How is it to be equivalently transferred to the whole plane, or to that part of it outside the leads, so that it may generate plane waves of the precise type belonging to the given leads? This is by no means so easy to follow up as the previous plate substitutions; but the following may sufficiently describe the essence of the transformation. First, when the generation of disturbances is concerned, it is not impressed electric force **e**, but its curl, that is effective. We must therefore find the curl of the given impressed force. If the latter is half in each wire, acting opposite ways, and uniform across their sections by the reference plane, then the curl of **e**, say **f**, is situated on the boundaries of the wires, and encloses them. Having ascertained the integral amount of **f**, it must be transferred to the whole reference plane outside the wires. Then the question arises how to distribute it properly. To answer this, it may be mentioned that when a distribution of

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f starts into action, the first effect is to generate induction following the lines of f. This will be made clear later. If, therefore, we distribute the lines of f over the reference plane in such a way as to exactly copy the natural distribution of the magnetic lines in plane waves having the given leads for cores, we shall obtain what we want, viz., the sources so distributed as to generate plane waves of the required type on the spot.

By means of the above and similar devices, most telephonic and telegraphic problems may be converted to problems in an exact plane-wave theory. But we must always be careful to distinguish between a theory and the application thereof. The advantage of a precise theory is its definiteness. If it be dynamically sound, we may elaborate it as far as we please, and be always in contact with a possible state of things. But in making applications it is another matter. It requires the exercise of judgment and knowledge of things as they are, to be able to decide whether this or that influence is negligible or paramount.

(To be continued.)

THE HOLDEN-D'ARSONVAL UNIVERSAL REFLECTING GALVANOMETER.

The ordinary D'Arsonval reflecting galvanometer, which consists of a suspended coil placed in a strong magnetic field, is too well known to our readers to need description here. This instrument has received several important modifications at the hands of Major Holden; and the new instruments, which are manufactured by Mr. J. Pitkin, are now being put on the market by Messrs. Drake and Gorham, who are also the agents for other measuring instruments invented by Major Holden (see *The Electrician*, Vol. XXIX., p. 589). One of the most

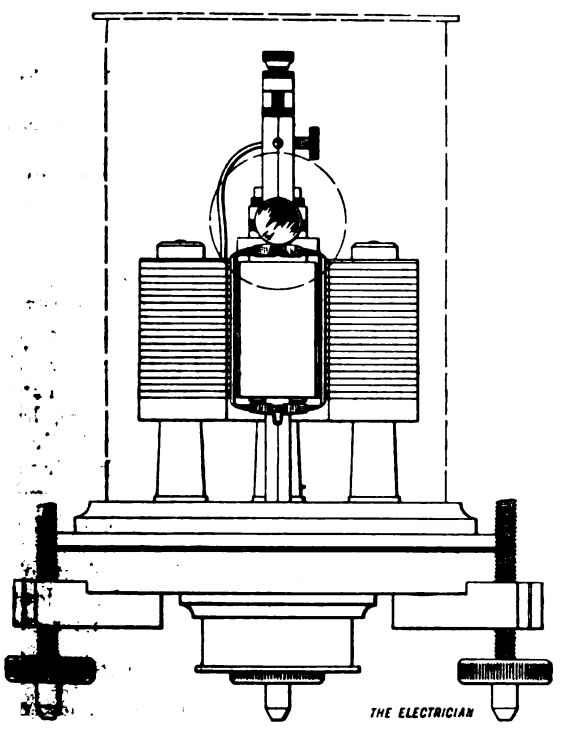

FIG. 1.—Holden-D Arsonval Galvanometer. Elevation

useful alterations and improvements is the arrangement which is made for quickly and expeditiously removing the suspended coil and its setting, and replacing it by another coil of different resistance, or by the hot-twisted-wire apparatus for alternating currents. The complete instrument is provided with a number of these interchangeable fittings, and the change from one to any of the others can be made without altering the adjustment as a whole on the testing table. The general form is shown in elevation in Fig. 1, and in plan in Fig. 2, and both these diagrams show one of the ordinary rectangular coils suspended in the field of the circular steel magnets.

The coil and frame is shown in Fig. 3. The coil is suspended on a fine strip made of flattened phosphor bronze wire. It is wound upon a light metal former; this former consisting, as it does, of a closed metal current, quickly damps the oscillations when it is placed in the magnetic field. The frame is provided

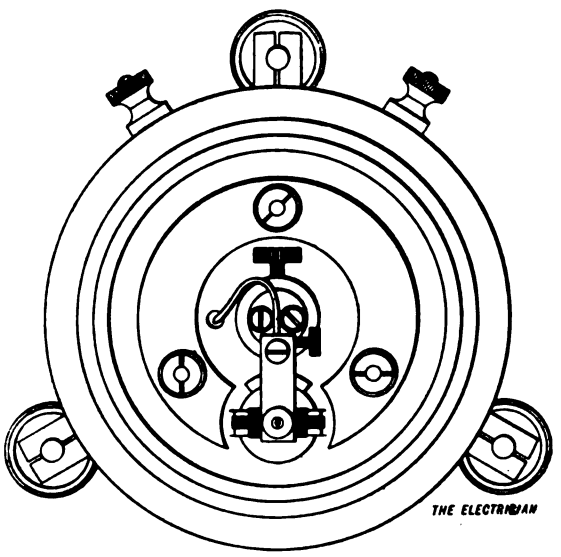

FIG. 2.—Holden-D'Arsonval Galvanometer. Plan.

with a tension screw at the top and a torsion head below. This torsion head can be got at by removing the lower cap without disturbing the cover of the instrument, thus enabling the spot of light to be brought approximately to zero. A cylindrical iron core is carried on the frame and is embraced by the coil. This core is screwed to a brass plug, which slides into a hollow cylinder fixed centrally into the instrument. The upper part

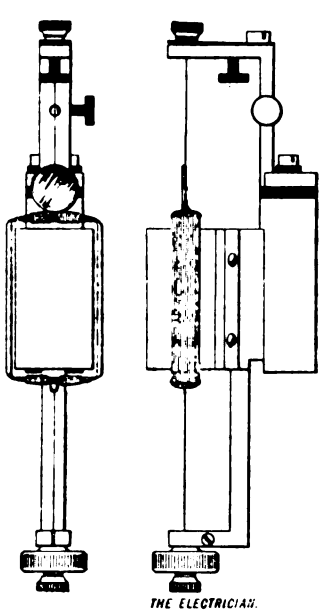

FIG. 3.
Coil and Frame.

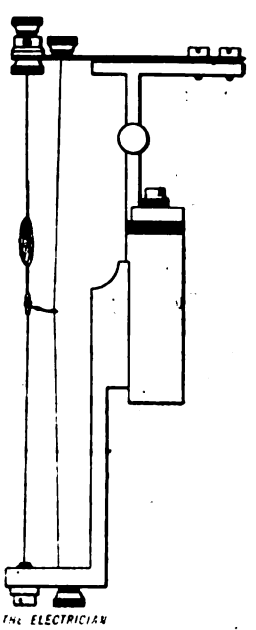

FIG. 4.
Hot Wire Frame for Alternating Currents.

of the frame is carried off this plug, and is insulated from it. A flexible wire connects this upper part with one of the terminals, the circuit being completed through the socket and the pillars. Each frame is thus held in a definite position, and, being provided with its own core, the constant of each frame and coil remains unaltered.

Not content with adapting this form of galvanometer for all purposes of continuous-current measurement, Major Holden has devised two methods of using it with alternating currents.

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The rectangular coil is replaced by a vertical fine wire of platinum-iridium, through which the current is passed. This is shown in Fig. 4. In this latter adaptation the magnetic field is, of course, not utilised; but the device is carried on a plug which fits into the socket which holds the other frames. These are measured by means of the expansion of a thin wire, which acts upon a mirror so as to give it a turning movement. Between the two ends of the frame are fastened two wires having the same coefficient of expansion. These wires are insulated from each, and the current only passes through one of them. They are both kept tight by a spring which is adjustable and to which they are both connected.

The front wire carries in the centre of its length a small spindle to which is attached a silvered glass mirror. Around this spindle beneath the mirror is wrapped a very fine silk thread, the other end of which is connected to the back wire which carries the current. A torsion head attached to the front wires enables this to be turned so as to put a strain on the silk and deflects the back wire slightly from its position. When the current passes, the back wire is heated and lengthens; this allows the mirror to turn under the influence of the torsion given to its suspension wire. Major Holden has devised an ingenious modification of the rectangular coil fitting, by means of which an alternate current is measured by a magnetic torque. In this the rectangular coil consists only of one turn, which completes a local circuit with a small thermopile, the entire circuit being mounted on the suspending wires. The thermopile is warmed, and sets up a local current in the rectangular coil by virtue of the passage of the alternating current through a resistance *in the immediate neighbourhood of*, but not connected to, the thermopile. The strength of the local current, and the amount of deflection it will produce, will vary with the strength of the alternating current to be measured.

Besides the obvious convenience which the instrument offers on account of the variety of auxiliary fittings with which it is provided, there are numerous other advantages. The magnetic field in the air spaces into which the rectangular coil is placed is designed with special regard to uniform intensity; so that the readings on the scale are as nearly as possible proportional to the current passing through the coil. Portability is given to the instrument by providing it with a device for clamping the coil; and dead-beatness, by winding the coil on a metal frame, the eddy currents generated in which by the strong magnetic field will rapidly damp out oscillations. The instrument in its standard form is more compact than, and, it is claimed, more sensitive than the older patterns of this type of galvanometer. The standard pattern is provided with four interchangeable coils and frames, namely:—(1) A coil of 500 turns, with a resistance of 600 ohms; (2) a coil of 250 turns and 265 ohms; (3) a coil of 125 turns and 133 ohms; (4) a coil of 250 turns and 70 ohms resistance. Besides these, there are a number of frames for special purposes, some of which we have already described. The 500-turn coil with 10 megohms added gives a deflection of 1 millimetre at 2 metres with 1 volt.

A CONTRIBUTION TO THE THEORY OF ALTERNATE-CURRENT ELECTROLYSIS.*

BY DR. RICCARDO MALAGOLI.

For the history of the subject, and for the criticism I made on the theory given by Mengarini in 1891,† I refer the reader to a recent article of mine‡. It follows from what I have there said that only the fundamental principle of this theory, originated for the first time by Mengarini, can be retained; that is to say, we can only assume that the electrolytic phenomena produced by alternate currents may be considered as an integration of the ordinary electrolytic effects occurring during each alternation of the current. It is, therefore, necessary to investigate the elementary electrolytic phenomena which exhibit themselves at every alternation by applying to a single alternation the well-known laws of ordinary electrolysis, and then to integrate with reference to the number of alternations the current makes in any given period.

Assume that we are sending an alternate current through a voltameter having equal electrodes, which are not attacked either by the electrolyte or by its decomposed elements. Since there is no formula expressing the value of the electromotive force of polarisation of a voltameter, even when it has attained its maximum, it is impossible to apply mathematics to the determination of the shape of the electromotive force of polarisation of the voltameter. The method I used to effect this determination was necessarily a minute study of several particular cases.

If 2 T be the period of the alternate current, then $\int_0^T I\,dt$ is the quantity $s\,q$ (where s is the active surface of each electrode) of electricity, which passes through the voltameter at each half period. Since, for the same voltameter and electrolyte, the electromotive force of polarisation is only a function of q, our investigations must be directed to this element.

If q_0 be the quantity of electricity which has to traverse each square millimetre of surface on each electrode in order that the voltameter may attain its maximum polarisation, and if r be the interval of time at the end of which the current I (when flowing in a given direction) succeeds in producing this maximum, the different cases which may arise are—

$$q < q_0 \qquad r > T$$

$$q_0 < q < 2\,q_0 \qquad \frac{T}{2} < r < T$$

$$q = 2\,q_0 \qquad r = \frac{T}{2}$$

$$q > 2\,q_0 \qquad r < \frac{T}{2}.$$

In the first three cases there is no electrolytic decomposition. The voltameter, however, has not a variable polarisation, and if we take into account the shape of the stable polarisation curve it will be seen that at the end of each phase of the current we get equal and opposite polarities, zero being at the instant $\frac{T}{2}$, so that the first half of $s\,q$ is employed in depolarising the voltameter, and the second is occupied in polarising the reverse way. Only when $q = 2\,q_0$ are the initial and final polarisations equal to the maximum. When there is no electrolysis the curve of polarisation has a lag of a quarter-period with reference to the current.

If $q > 2\,q_0$, $s\,q_0 = \int_0^r I\,dt$, and in the interval from 0 to r the voltameter will be depolarised, and if $2\,sq_0 = \int_0^{r'} I\,dt$, the voltameter in the interval r to r' will acquire a polarity of opposite sign to that of the initial polarisation, and in the interval r' to T of the elementary phase, electrolytic decomposition will be possible. The curve of polarisation will, therefore, be at a maximum at the commencement of each phase, and will assume a maximum of opposite sign after the time r', keeping at this maximum until the moment T. This curve, therefore, has a lag of r with regard to the current curve, and this lag will be smaller, the larger q.

To find the law of the phenomenon, it is sufficient to determine theoretically the amount of electrolytic products developed by electrolysis in any given interval of time, let us assume an ideal case, $I = A \sin \frac{\pi t}{T}$, and if the stable state of polarisation has already been reached, the moment r' of the elementary phase at the end of which electrolysis will begin is given by the expression,

$$2\,s\,q_0 = A \int_0^{r'} \sin \frac{\pi t}{T}\,dt,$$

or,

$$r' = \frac{T}{\pi} \operatorname{arc\,cos} \left(1 - \frac{2\,s\,\pi\,q_0}{A\,T}\right).$$

On the other hand, the quantity of electricity, to which the electrolytic decomposition produced during the elementary phase is proportional, is

$$Q_0 = \int_{r'}^{T} I\,dt = A \int_{r'}^{T} \sin \frac{\pi t}{T} dt = \frac{2\,A\,T}{\pi} \left(1 - \frac{s\,\pi\,q_0}{A\,T}\right).$$

* Abstract (by the Author) of a Paper read before the Accademia Gioenia di Catania.

† *The Electrician*, Vol. XXVII., July 17 and 24, 1891.

‡ *La Lumière Electrique*, Vol. XLVII., 1893.

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Taking $\frac{1}{T} = n$, the quantity of electricity which will pass through the voltameter during unit time of maximum polarisation, giving rise to electrolytic decomposition, will be

$$\frac{2A}{\pi}\left(1 - \frac{\pi s q_0 n}{A}\right).$$

Finally, if the phenomenon lasts (v) seconds, and if k is the electro-chemical equivalent, the liberated products in the voltameter will be represented by

$$Q = \frac{2A(v)k}{\pi}\left(1 - \frac{\pi s q_0 n}{A}\right).$$

Let me now explain the results contained in the preceding formula, results, which, as I have shown in the article referred to, are general. Assume that the current traversing the voltameter is supplied from a transformer feed by an alternator, so that we may assume that the number of alternations and current maxima are independent variables. Taking $A/S = \delta$ and observing that a negative value of Q has no meaning, we may arrive at the following conclusions from the above formula.

1. For every value of n there is a maximum current density δ, which is determined by the expression $1 - \frac{\pi q_0 n}{\delta} = 0$, at and below which electrolysis is impossible.

2. For every value δ' of the maximum current density above the preceding lower limit corresponding to a certain value of n, the phenomenon of electrolysis occurs even at a higher frequency, but there is a maximum limit n_0, determined by the expression $1 - \frac{\pi q_0 n_0}{\delta'} = 0$, after which electrolysis ceases and remains impossible for all values above n_0.

3. These limits depend upon q_0 and differ for different electrolytes.

4. Since the nature of the electrodes has no influence whatever on the value of the electromotive force of polarisation of the voltameter, provided they are not attacked either by the electrolyte or by its constituents, it may be inferred that the limits in question are also independent of the nature of the electrodes.

5. If the surface of the two electrodes is varied as well as the frequency, so that the product $s\,n$ remains constant, the electrolytic products obtained will also remain constant.

6. If only the current maxima are varied the resulting variations are not proportional.

7. If the current maxima and the surface of the electrodes, or the frequency, are varied in proportion, the corresponding variations of the amount of the electrolytic products are not (in the general case) rigorously proportional.

8. If only the electrode surface, or the frequency, is varied, the products obtained vary in opposite directions.

9. If the current is "redressed," the stable polarisation is (as in the case of a continuous current) represented by a straight line parallel to the axis of time, and in this case the products obtained are proportional to the total quantity of electricity traversing the voltameter; that which is used in polarising the voltameter being negligible. It follows from this that the amount of decomposed electrolyte is larger than it is in the case of an alternate current.

10. If on the same circuit several similar voltameters are arranged, containing unattackable electrodes and different electrolytes, the quantiy of electrolytic product obtained in each voltameter does not follow the laws of Faraday for ordinary electrolysis, since the energy spent in the polarisation and depolarisation of the voltameters is different.

All the experimental laws laid down by Mengarini are included in the above, excepting always that relating to the nature of the electrodes, which is not, moreover, of essential importance.

The formula $Q = \frac{2A(v)k}{\pi}\left(1 - \frac{\pi s q_0 n}{A}\right)$ which expresses the amount of electrolytic product liberated during the time (v) by the action of the current $I = A \sin \frac{\pi t}{T}$, may be considered as the pure and simple interpretation of experimental results obtained, and I may put forward a simpler form. The quantity of electricity which traverses the voltameter during a single phase of the current is given by the expression,

$$Q_e = \int_0^T I\,dt = \frac{2AT}{\pi} = \frac{2A}{n\pi}.$$

Substituting in the expression for Q, we have

$$Q = (v)\,n\,k\,(Q_e - 2\,s\,q_0),$$

and as $s\,q_0$ represents the quantity of electricity which must pass through the voltameter to allow it to obtain maximum polarisation, if we denote this quantity $s\,q_0$ by Q_0 the formula becomes

$$Q = (v)\,n\,k\,(Q_e - 2\,Q_0),$$

where $(v)\,n$ represents the number of alternations comprised in the interval in question. This new form shows that:—*The necessary and sufficient condition of alternate-current electrolysis is that the quantity of electricity which passes through the voltameter during a single alternation should be greater than twice that which is necessary to give to the voltameter its maximum polarisation. Electrolytic production ceases the moment these two quantities are equal, and the amount of decomposed electrolyte is proportional to the difference of these two quantities.*

M. VIOLLE ON THE LIGHT OF THE ELECTRIC ARC.

At a recent meeting of the International Society of Electricians, on the 7th inst., M. Violle described the experiments which he had been making on the electric arc. This experimenter has found that the light intensity of the positive carbon remains sensibly constant when the power supplied is varied in the proportion of 1 to 60. He has employed two methods of measurement: that of the spectrophotometer, the accuracy of which is really much greater than is usually stated to be the case; and a second method due to Arago, employing interference fringes. M. Violle exhibited a number of photographs of arcs of different candle-power, in order to show the constancy of the intensity of the positive carbon. By measuring the opacity of the negative plates, these photographs could be used as a gauge of the intensity. M. Violle recalled that this phenomenon had already been investigated by Rosetti, as well as by Capt. Abney and Silvanus Thompson; and everyone had attributed it to vaporisation of the carbon. This opinion was perfectly justified, for the deposit on the negative carbon has the appearance of having been condensed from vapour, and M. Violle had actually been able to produce crystals on this part. A photograph of an arc produced between carbons of purified retort carbon was next shown, and this exhibited a very curious appearance. Despretz had also observed that the phenomenon was due to volatilisation, but that there was fusion or more or less softening of the carbon; he had also attributed the deposit of carbon, which is formed in the arc, to the condensation of vapour of carbon, but he was unable to elucidate the question because he used impure carbons. M. Blondel has recently recognised that impurities in the carbon have not, in practice, any sensible effect on the intensity, which remains constant with carbons of very different quality. The intensity of the arc, he thought, was therefore a constant, and it might be utilised as such. M. Violle stated, in conclusion, that the temperature of 3,500°C. which is given for the arc, ought to be considered as a provisional value, although the true temperature is probably but little different from this figure.

Electric Light at the Krupp Works.—The electric light plant at the Krupp works, in Essen, which was commenced in 1876, has recently received considerable extension. The generating station is situated near the centre of the works, and includes six dynamos and steam engines of an aggregate of 650 H.P. There are two separate systems of distribution; one at 100 volts, continuous-current, for the glow lamps in the offices and workshops; and the other at 700 volts, continuous-current, for the arc lighting circuits and, by means of continuous-current transformers, for the more remote glow lamps. The low-pressure circuit consists of 3,200 metres of underground cable, feeding 1,400 glow lamps. The high-pressure cables are conveyed from the central station to three distributing stations at a distance of 4,900 metres, whence they radiate to the numerous arc lamp circuits which are carried overhead. Each of the arc lamp circuits consists of 16 lamps in series, and supplies 10 amperes. There are 384 arc lamps on all the circuits

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THE REGULATION OF ELECTRO-TECHNICAL LITERATURE.

The art of destroying old books is one of the many pernicious growths of these later times, and one that has attained a remarkably high state of development—as any British Museum Reading-room attendant will tell. The time-honoured recipe of giving an old volume a thorough stretching, followed by a prolonged course of reading in front of a log-fire, is only practised in these days by tyros. On the other hand, the useful art of destroying new books is in a disgracefully rudimentary stage. The smart reviewer, indeed, does his duty manfully, but, notwithstanding his efforts, he remains, when viewed in his proper light as a book-slaying machine, a most inefficient piece of apparatus. A good modern dynamo will return 97 out of every 100 watts put into it, mechanically; would that a reviewer could smash, pulverise, and annihilate 97 out of every 100 volumes that come within his range. The tide of electro-technical literature is flowing strongly just at present, and flowing as it does, in the direction of profit, no one feels inclined to take it at the flood and try to stem it after the manner of King CANUTE. Those who take a pride in thoroughness lament the existence of this literary Niagara, and the reviewers pound away with the heavy artillery of oracular castigation and the light guns of sarcasm and irony. But to no purpose. The lamentations are unheard and the witticisms unheeded. Both the one and the other serve merely as a sort of cerebral safety-valve to the individual who indulges in them. As the papers related but a few days ago, a piece of slovenly riveting on the part of a workman went nigh to endangering a four-million-dollar man-of-war. We wish it were possible to calculate the damage done by bad workmanship on the part of those who render themselves

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responsible for technical books. Putting aside blunders, how much valuable time is wasted owing to obscurities of style, and to the undue prominence given to theoretical or mathematical futilities ?—defects originating nine times out of ten in lack of knowledge, lack of literary skill, and slovenly workmanship. If we add to the time so wasted the time spent in unlearning and find the ratio which the sum of these two items bears to the waking working hours of the average man, surely retributive justice is painfully and inadequately represented by a smart review which advertises as much as it damns. The solemn and formal bastinado of the author, followed by an *auto-da-fé* of his works, would seem more commensurate with the offence.

The evil is, alas, of long standing. Twenty years ago the Comte DU MONCEL, his own literary perpetrations notwithstanding, prefaced the 3rd Edition of his three-volumed "Exposé des Applications de l'Électricité" with a lengthy diatribe. "These books," said DU MONCEL, referring to those of the popular science order, "have put really serious works out of countenance; works in which real science is more difficult to acquire, and the majority of publishers, naturally more concerned with their own interest than those of science, rarely undertake now-a-days the publication of truly scientific works. On the other hand, if the superficial knowledge required by the perusal of works, such as I am speaking of, has given rise to investigation and invention, how many illusions have they not also given rise to? . . . A number of these books, moreover, are written by people who are not specialists in the subjects with which they deal; who only know science at second-hand without the mathematical and theoretical knowledge necessary for a just appreciation of the facts; and who, not grasping principles, only attach importance to form, and to the effect produced upon the reader. A great personage whom it was proposed to transform from a man of letters into a statesman, remarked that a hare was a necessary antecedent to jugged hare. In the same way, some knowledge of science is of necessity antecedent to a scientific book, even of the popular order. . . . . But such is not the spirit which pervades popular science publications to which the Press daily gives birth. Sensational inventions and phenomena which appear most likely to dazzle the mind are picked out and described somewhat after the manner of conjurors, and the public, but slightly in touch with true science, believes that all has been said that can be said. For instance, many books specially devoted to electricity allot an undue proportion of their space to tricks and devices employed on the stage by conjurors to attract the public attention, whilst no mention is made of the admirable applications of electricity to apparatus of precision, to chronographs, meteorological apparatus, the art of engraving and similar industries. In the many curious phenomena of induced currents of high tension such writers only see the illumination of tubes more or less ingeniously arranged to produce the maximum luminous effect. What is still more strange is that the majority of the books in question are cast in the same mould. It would seem as if certain inventions, which have been the subject of more or less interested puffing, had been taken as their theme as well as certain ill-digested discoveries; whilst, in regard to the others, the word had been sent round to maintain a conspiracy of silence."

Let us, then, pending the slow evolution of an automatic extinguisher of flat, stale, and unprofitable scientific books, by the gradual education of the public taste, endeavour to improve upon the reviewer. We have already hinted at the introduction of foreign methods, and the same source is fruitful of similar expedients for training up public opinion in the way it should go. Electro-technical Institutes abound; cannot we institute an electro-technical version of the old Congregation of the Index, charged with the important function of sitting upon all names of printed puerilities of an electro-technical kind. Given sufficiently eminent specialists at sufficiently high salaries, acting as censors and licensors of electrical literature, we predict the sudden demise of 95 per cent. of existing books and rioting in Trafalgar-square by out-of-work reviewers. A perusal of MILTON'S "Areopagitica" might possibly give rise to misgivings in some minds as to the expediency of such an institution. "As good almost kill a man as kill a good book." Why, certainly; but what if a thousand bad books are destroyed at the same time? The censors might license none but their own books. Any censor directly or indirectly concerned in the writing of a book should be *ipso facto* disqualified. The standard might be raised too high. Possibly. But at first the datum line might be drawn at any text-book, hand-book, pocket-book, or similar publication that did not contain a minimum of one fresh idea and one new illustration. We make the suggestion for what it is worth, even though its figure of merit be only "one *ob.*" Provided the floodgates of literary futilities be kept shut, at least for a time, no one need inquire too closely as to the means.

THE INCANDESCENT LAMP: ITS MANUFACTURE AND USE.*

BY GILBERT S. RAM.

The light-emitting portion or burner—called by Edison the filament—of the incandescent lamp, it is well known, is composed of carbon, which is raised to a state of incandescence by the passage through it of a current of electricity. Carbon is not the only substance which can be used. The number of possible materials is, however, very small, and for two reasons. Firstly, because the material must be capable of withstanding a very high temperature; and secondly, because it must be a conductor of electricity. These two conditions exclude nearly everything except carbon and some of the metals. Of the metals which are sufficiently plentiful, platinum alone possesses the desired qualifications to a degree which renders its use possible. Platinum has a very high melting point, and will stand a very high temperature, but the temperature necessary for an economical incandescent lamp burner is far above that even of the melting point of that metal.

The incandescent electric lamp, though a great advance upon most other artificial sources of illumination, gives us at best only a very inefficient method of obtaining light. That is to say, the proportion of the luminous radiation to the total radiation is very small. When the temperature of a filament is raised by the expenditure in it of more and more energy it becomes increasingly efficient. The efficiency which can be attained is however, limited, by the temperature which the filament will stand. Carbon will stand a temperature higher than the melting point of platinum, and it, therefore, constitutes a more efficient burner.

Certain metallic oxides possess in a remarkable degree the power of resisting very high temperatures. It has, in consequence, been proposed to utilise these in some way, and mention of them has been made in some of the earliest patents for electric lamps. Here, however, the difficulty occurs that metallic oxides are non-conductors of electricity, and, consequently, cannot be used alone. They can only be used in conjunction with some conductor—either a metal or carbon. The author has tried coating both platinum and carbon with oxides such as alumina, magnesia, lime, &c., but has always met with the difficulty, in the first place, that the coefficient of expansion

* Abstract from a book to be published shortly by "*The Electrician*" Printing and Publishing Company (Limited). All rights of re-publication reserved.

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of the oxide is different from that of the carbon or metal, and, consequently, the coating cracks and falls off.

It has been pointed out by Prof. S. P. Thompson that the temperature of the crater of the arc in an arc lamp is constant, and is the temperature of the volatilisation of carbon. Any other substance contained in the carbons volatilises instantly when reaching the arc. The carbon itself volatilises at that temperature, and all other substances appear to do the same either at that temperature or below. This being the case, it would appear futile to attempt to increase the durability of arc lamp carbons by the addition of any foreign substance.

It is possible, however, that some substance other than carbon may yet be used successfully as the light-emitter in an electric lamp. Even if all metallic oxides are dispersed at a temperature less than that of the arc when used in conjunction with carbon, they are not all necessarily volatilised at that temperature. The volatilisation may be simply a secondary effect, the oxide having been first reduced by the carbon. It does not appear to be impossible that some oxide or mineral substance may be found to be stable at temperatures higher even than that of the arc if there be no carbon present. The great trouble in using any such substance in the same manner as the filament of an ordinary incandescent lamp is that of electrical conductivity. It is possible that some of them might consent to conduct sufficiently if subjected to a very high E.M F., such as can be produced by transformers. We have seen during the past year slate pencils used in the place of carbons in the arc lamp, slate being considered an insulator at ordinary electrical pressures. Such an incandescent lamp, however, if ever constructed, would hardly be suitable for domestic use. Again, although mineral substances when mixed with carbon are all reduced or volatilised in the arc, such mixtures may, nevertheless, be used for incandescent lamp filaments at a temperature much below that of the arc.

Great improvements may yet, however, be looked for in the carbon itself. It is well known that carbon prepared by some processes will last much longer than that prepared by others. The efficiency of a carbon depends upon the temperature at which it can be run. The higher the temperature the greater the efficiency. The limit to the temperature possible is that of the volatilisation of carbon. This temperature in the case of an incandescent lamp is probably lower than that of the arc. The temperature of volatilisation of carbon in vacuo is likely to be much less than at atmospheric pressure. We can, therefore, never hope to get the carbon of an incandescent lamp anything like as bright as the crater of an arc lamp.

Long before the temperature of volatilisation of carbon in vacuo is attained, there is another effect to be considered which puts a far lower limit upon the temperature which can be maintained in practice. Apart from volatilisation properly so called, there is an action going on by which particles of carbon are dissociated from the filament and thrown off upon the glass globe (which is usually called the bulb) of the lamp. This action, unfortunately, begins at a comparatively very low temperature—a little above red heat—and increases very much at higher temperatures, so that, although the filament may be far below the temperature of volatilisation, yet it is fast falling to pieces, and the bulb is becoming greatly obscured by the black deposit of these particles of carbon. It is, then, in overcoming this lower limit to the temperature that improvements must first be made. Some carbons are much better than others in this respect. The best carbon is that which at the highest possible temperature disintegrates at the slowest rate.

Much has been said and written about the so-called efficiency of surface, or emissivity, of different varieties of carbon. Some varieties have a greater emissivity than others in the proportion of about 3 to 2. That is to say, when running at the same efficiency (watts per candle), two carbons of precisely the same dimensions may be giving different amounts of light by as much as the above ratio. Or two carbons, one having only two-thirds of the surface of the other, may, when at the same efficiency, be giving an equal amount of light. It has sometimes been supposed that the one with the smaller surface is, therefore, better than the other. The reverse, however, is usually the case. The filament with the smallest emissivity is generally the best. A high emissivity usually means a dead black surface, a low emissivity, a polished white one. The dull black surface is generally a softer carbon, and one which disintegrates more quickly than the other. The only advantage in the high emissivity is that the filament is, therefore, shorter and may be accommodated in a smaller bulb. The size of the bulb, however, should not be determined by the length of the filament so much as by the candle-power. A large candle-power lamp may have a short filament, but it should not for that reason be put into a small bulb. These matters will be further dealt with in a subsequent chapter.

The chief aim of the lamp-maker, next to that of producing a durable carbon, is to make filaments which will be all alike when finished. To be commercially successful a lamp-maker must be able to make his filaments within a very little all alike in every particular, that is in dimensions (length, circumference, cross-section), in quality of surface and in specific resistance. Many different methods of preparing carbon have been proposed. Whatever the method, there is one operation which almost all of them necessarily include—that of roasting or baking the material in a furnace out of contact with the atmosphere, in order to drive off, as far as possible, everything contained in the material which is not carbon. In most cases an entire change in the nature of the material is produced by the process. One of the first methods to be tried was that of forming the filament out of a paste made of ground carbon, with a binding agent such as a solution of sugar or caromel. Such a paste was squirted or moulded to the desired shape, dried, and then baked. This, of course, produced practically the same material as is used for the carbons of arc lamps. The difficulty in this method is to produce fine and uniform filaments. In any event, however, the resulting carbon is not compact enough for the purpose, and it rapidly disintegrates when used in a lamp. Edison proposed a mixture of lamp-black and tar, an utterly worthless process in itself, but one which has, nevertheless, become famous in the history of lamp making. Processes such as these involve the baking of the material in order to drive off the volatile matter contained in the binding agent.

The successful processes are not those by which the filaments are formed direct from a substance containing carbon as such, but from a material containing carbon in chemical combination, such as silk, hair, woody fibre, or pure cellulose. Such substances require baking at a high temperature in order to reduce them to carbon, their other constituents being driven off by the heat. The process of baking in this case is generally called carbonisation. The only processes which do not include that of baking or carbonisation are those by which the filaments are deposited or built up from the carbon contained in some vapour or liquid such as illuminating gas or petroleum oil.

(*To be continued.*)

ON THE MEASUREMENT OF INTERNAL RESISTANCE OF PRIMARY BATTERIES WHICH POLARISE.

BY E. C. RIMINGTON.

To obtain the internal resistance of a primary battery appears at first sight a very simple affair. If any text-book on electrical testing be consulted a great many different methods will be found, any one of which is supposed to be capable of giving the desired result. As long as the primary battery to be tested is of a kind very slightly subject to polarisation, such, for example, as a Daniel cell, this is probably true, and one method will give a value for the internal resistance differing but slightly from that obtained by another. If, however, the resistance of a battery subject to polarisation, such as a Leclanché or any of the dry forms of cells, be measured by two different methods, or even twice by the same method,

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values which differ very considerably from each other will be obtained.

It is well known that all methods for measuring internal resistance consist in practically making two measurements, the battery giving a different current in each case. Now if there be any polarisation the electromotive force of the battery, instead of being constant, which it is supposed to be in getting out the result, will be a function of the current being less as the current is increased; this will, of course, produce an error which may be very considerable. One of the most usual methods of determining internal resistance is the following, or some slight modification of it.

The battery of internal resistance ρ, which is to be found, is circuited through a resistance R, and its terminal potential difference is measured, let the latter be V; the battery is then circuited through an external resistance r, and the terminal potential difference again measured; call it v.

Then
$$\frac{V}{v} = \frac{\frac{\rho + R}{\frac{r}{\rho + r}}}{} = \frac{R(\rho + r)}{r(\rho + R)},$$

or,
$$\rho = \frac{R r (V - v)}{R v - r V}.$$

As the potential differences occur as ratios it is unnecessary to know their value in volts, so that if the instrument used in measuring them give deflections proportional to the potential difference at its terminals, then if D and d are the respective deflections

$$\rho = \frac{R r (D - d)}{R d - r D} = \frac{r (D - d)}{d - \frac{r D}{R}}. \quad . \quad . \quad . \quad (1)$$

In practice R is generally infinite, or the deflection D is taken with the battery uncircuited; then

$$\rho = \frac{r (D - d)}{d}.$$

The deflections D and d can be obtained by connecting a high resistance proportional reading galvanometer across the battery terminals to act as a voltmeter, or by charging a condenser from the battery terminals and discharging it through a galvanometer: this latter is generally known as Kempe's method.

Major Holden's instrument for testing primary batteries, described in *The Electrician*, June 23rd, p. 200, works on this method; in it R = 8 ohms and r = 2 ohms. The resistance of the coil, which acts as a voltmeter, is not stated, but it is probably sufficiently high to make its joint resistance in parallel with the 8 ohms very little less than 8 ohms.

Let us consider the probable error produced in measuring the resistance of a cell or battery by this method, assuming that there is *no* polarisation.

From equation (1) $\rho = \frac{R r (D - d)}{R d - r D}$.

Assume an error x made in the value of d. Then the value of ρ (or ρ_1) becomes

$$\rho_1 = \frac{R r (D - d - x)}{R (d + x) - r D}.$$

The error in ρ is

$$\rho - \rho_1 = \frac{R r (D - d)}{R d - r D} - \frac{R r (D - d - x)}{R (d + x) - r D}$$

$$= \frac{R r (R - r) D x}{R d - r D) \{R (d + x) - r D\}}$$

$$= \frac{R r (R - r) D x}{R d - r D)^2} \text{ approximately.}$$

Hence the fractional error in the value of ρ;

or
$$f = \frac{\rho - \rho_1}{\rho} = \frac{(R - r) D x}{(D - d)(R d - r D)}. \quad . \quad . \quad . \quad (2)$$

If R = ∞ (2) becomes

(2a) $f = \frac{D x}{(D - d) d}$ and the value of d that makes f a minimum is obviously $d = \frac{D}{2}$, so that r should be approximately equal to ρ.

In Major Holden's instrument R = 8, r = 2.

Therefore
$$f = \frac{3 D x}{(D - d)(4 d - D)}.$$

In the illustration given of the instrument the scale reads to 0·1 of a volt, but from the column of figures of measurements made with the instrument it apparently reads to 0·01 of a volt. Let us suppose 0·01 as the probable error in taking a reading. Taking the third test given, viz., that of an E. C. C. dry cell, D = 1·43, d = 1·38, the probable value of f

$$= \frac{3 \times 1{\cdot}43 \times 0{\cdot}01}{(1{\cdot}43 - 1{\cdot}38)(5{\cdot}52 = 1{\cdot}43)} = 0{\cdot}21,$$

or 21 per cent. is the probable error in the value of ρ.

In the case of No. 4, a Leclanché-Barbier dry cell of considerably higher internal resistance than the E. C. C., D = 1·3, d = 1·05,

$$f = \frac{3 \times 1{\cdot}3 \times 0\ 01}{(1{\cdot}3 - 1{\cdot}05)(5{\cdot}2 - 1{\cdot}3)} = 0{\cdot}04, \text{ or 4 per cent. only.}$$

We must now consider the effect of polarisation. When the cell is circuited through the lower resistance, it gives a larger current, and has, consequently, a smaller electromotive force, its potential difference will therefore be less than it would have been if there had been no polarisation. In formula (1) the value of d will read too small, and as it can be readily seen this will make the observed value of ρ greater than its real value.

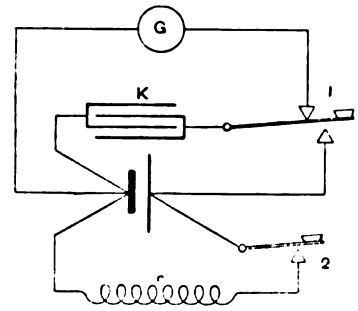

FIG. 1.

This error, due to polarisation, is a very serious one in cases of all cells such as Leclanché or dry cells, and may make the worked out value of the internal resistance more than double its real value. The author, some years ago, made a large number of experiments on determining the internal resistances of Leclanché cells by Kempe's method and various modifications of it to try and obtain the method that would give the value of ρ nearest its true value. He found that the best results were obtained by circuiting the battery through a resistance about four to six times it internal resistance until its terminal potential difference had attained a fairly constant value, then breaking the circuit and *instantly* measuring the potential difference in open circuit.

The best method of doing this is shown in Fig. 1. K is a condenser. Key (2) is clamped down, and the terminal potential difference observed at intervals by pressing key (1) so as to charge the condenser, then releasing it and allowing the condenser to discharge through the galvanometer G. When a constant throw d is obtained, key (1) should be depressed, key (2) released, and *immediately* afterwards key (1); the throw D obtained will be that due to the electromotive force of the battery when polarised, or its potential difference in open circuit. Then, of course,

$$\rho = \frac{r (D - d)}{d}.$$

Theoretically, the best value to give r is equal to ρ, so as to make $d = \frac{D}{2}$; but this value would make the battery polarise to excess, to say nothing of running it down, so that the value given for r, viz., four to six times ρ, or even greater, will be found to give better results; in fact, the larger r can be made

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the better, provided the difference between D and d is sufficient to prevent a small error made in the reading of either producing too large a fractional error in the value of ρ. Now we know

$$\frac{d}{D} = \frac{r}{\rho + r},$$

and formula (2a)

$$f = \frac{D\,x}{(D-d)\,d}.$$

If $r = \rho$ $\quad d = \frac{D}{2}$ and $f = \frac{4x}{D}$

$r = 4\rho$ $\quad d = \frac{4}{5}D$ and $f = \frac{25\,x}{4\,D} = 6{\cdot}25\,\frac{x}{D}$,

$r = 6\rho$ $\quad d = \frac{6}{7}D$ and $f = 8{\cdot}1\,\frac{x}{D}$,

$r = 8\rho$ $\quad d = \frac{8}{9}D$ and $f = 10{\cdot}1\,\frac{x}{D}$.

It will be seen that making $r = 6\rho$ only makes the fractional error in ρ due to a given error of observation about double what it would be if $r = \rho$, but it will make the error due to polarisation very much less. Of course, the above remarks concerning the best value to make r apply to any of the methods of measuring internal resistance by observing the potential differences on open circuit, and with the cell circuited through r.

If it be desired to employ a galvanometer as a voltmeter instead of the galvanometer and condenser in the above method, the galvanometer should be as dead beat a one as possible, such as a d'Arsonval; even with this, however, it will not be

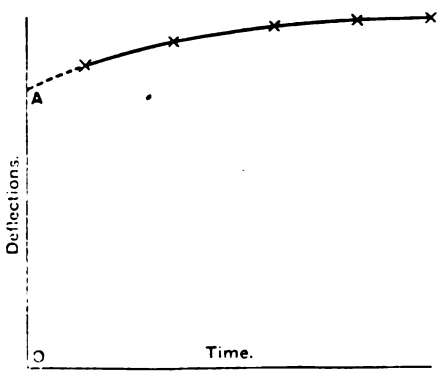

Fig. 2.

possible to obtain a reading at the instant of breaking the circuit through r, and the reading will be continually increasing, due to the cell recovering from polarisation. The following procedure may then be employed. Note the time at the instant of breaking the circuit r, then take time readings of the deflection, reckoned from the instant of breaking the circuit, and beginning as soon as the deflection is readable. On a piece of squared paper, plot times as abcissæ, and the readings as ordinates, this will give a curve somewhat similar to Fig. 2, where the crosses represent the readings. This curve can then be produced backwards by hand fairly accurately, as shown by the dotted line, and the reading at the instant after the circuit is broken, or D, will be approximately given by O A, the reading where the dotted curve cuts the vertical axis.

Of course this method has the disadvantage of running down the cell to be tested, as it is generally found necessary to keep it circuited for a good many minutes through r before it has polarised down to a fairly constant electromotive force, but it was found that much more consistent results could be obtained by this than by any other modification of the potential-difference method, and, moreover, ones that agreed much more closely with those given by more accurate methods of determining internal resistance as described below.

Any test for internal resistance founded on the determination of either the potential difference or the current when the battery is circuited through two different resistances can, however, never give really accurate results if there is much polarisation, since the most that can be done is to try and allow approximately for the effects of this polarisation, or obtain the reading very rapidly, as in the case of the condenser method, before polarisation or recovery from it have become appreciable, and this is very difficult to do effectually.

There are, however, methods by which polarisation can be absolutely eliminated; they possess the advantage, moreover, of being balance methods, and are, therefore, susceptible of greater accuracy than tests depending on the reading of deflections or throws, independently of their elimination of polarisation. One of these is a modification of the method of making Lord Kelvin's well-known test for internal resistance by turning it into a balance method, and invented by the author six or seven years ago, though it has not to his knowledge been hitherto published. Lord Kelvin's test consists in circuiting the battery to be tested in series with an adjustable resistance and a galvanometer, and noting the deflection, a shunt is then applied to the battery,

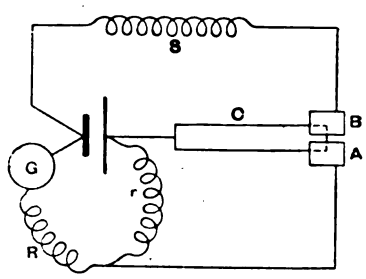

Fig. 3.

and the adjustable resistance reduced until the deflection is the same as before. Then if S is the resistance of the shunt, r the amount, by which the adjustable resistance has been reduced, $R + r$ its original value, and G the galvanometer resistance.

$$\rho = \frac{r\,S}{G + R}.$$

The test as it stands is practically useless if the battery to be tested polarise to even a slight extent, as the electromotive force when the shunt is on will be less than what it is with no shunt, while the formula is obtained on the supposition that the electromotive force is the same in the two cases. Suppose the above test to be connected up as shown in Fig. 3, using a key with a movable lever c, making contact *simultaneously* with the two contact pieces a and b when depressed; this has the effect of putting on the shunt and cutting out r at the same instant, so that if r be correctly adjusted, and there be no polarisation, the deflection on the galvanometer G would remain

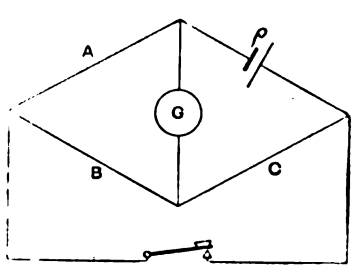

Fig. 4.

unchanged, and the test becomes a balance method instead of a reproduced deflection one. When r is too large, the deflection will increase on pressing the key, and when r is too small, decrease.

Suppose, now, that we are testing a cell which polarises; on pressing the key the cell gives more current, and its electromotive force falls off, so that, even if there were an exact balance supposing no polarisation, there will be a diminution in the deflection on account of this falling off in electromotive force. Any fall in the deflection on pressing the key must be then due to either or both of the two following causes: (1) r too small; (2) polarisation. The slightest movement of increase of deflection on pressing the key, even if immediately followed by a decrease, can only be due to r being too large.

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egin, then, by adjusting r until, on pressing the key, a ement of increase is obtained; this movement will be iediately followed by one in the direction of decrease, and to polarisation. Then gradually reduce r, until, on press- the key, there is just no movement of increase, while, if r ery slightly increased, the movement of increase of deflec- is again visible. This value of r will be the one that must sed in the formula. In this manner the effect of polarisa- is completely eliminated, however badly the battery to be d falls off in electromotive force. Of course the galvano- r is used to a false zero, the index being brought on to the by means of a neutralising magnet, or another coil carry- a circuit.

he best conditions for this making test are to make r large, consequently S small; S should not, however, be made too ll, on account of running down the cell; the effect on the ıarisation does not, of course, matter; somewhere rather ıter than ρ is probably the best value for S, if allowable, of course, r must be less than $G+R+r$, and this latter uld be as small as will allow a convenient deflection to obtained, using a very large false zero.

The objection to this method of determining internal resist- e is the difficulty of making a key, in which the con- t of c with a and b takes place absolutely simultaneously; best form is probably a long plunger, fitting accurately in ylinder for the movable piece c. The author has, however, ained very fair results with a form made like an ordinary ng contact key, but with two contacts and contact pieces ead of the ordinary single one; great care had, however, to mployed in using it, as the slightest twist in pressing it ed one contact to be made slightly before the other.

robably the best and most accurate method of taking rnal resistance is Mance's Bridge method (as in Fig. 4), A B being the ratio arms of the bridge and C the adjustable a. C is adjusted until there is no alteration in the deflec- n whether the key be up or down, that is if there be no arisation then $\rho = \frac{A\,C}{B}$. If, however, the cell polarises, the ct of the polarisation must be eliminated by the method of cedure given in the last test, over which it possesses the vantage of requiring no special form of key but simply an linary make-and-break key.

STRUCTIONS FOR PREPARING CLARK STANDARD CELLS.*

BY DR. K. KAHLE.

The instructions here given for the preparation of Clark cells are npiled on the basis of the experience gained in the Reichsanstalt, d are intended to place a reliable cell within the reach both of estigators requiring a standard of E.M.F. for their work, and of rkshops supplying such cells for technical purposes.

Besides the form of element here recommended, which may be ced back to the **H** form proposed by Lord Rayleigh, there are ny others, such as that proposed by the English Board of Trade d by Dr. Feussner. The considerations which gave rise to the rm here described are mainly the following:—The cell was to be sily reproduced and at the same time portable, and its E.M.F. ıs to adjust itself rapidly to changes of temperature. That the w cell is in these points to be preferred to the older patterns ll be shown in detail in a communication shortly to be published a continuation of the Paper published by me in this journal, 92, p. 117, "Contributions to the Study of the E.M.F. of the rk Standard Cell." The instructions concerning the chemicals be used in the cell appiy everywhere, and do not differ mate- lly from those given in the third Board of Trade Memorandum the Preparation of the Clark Standard Cell.

Definition and Properties of the Cell.

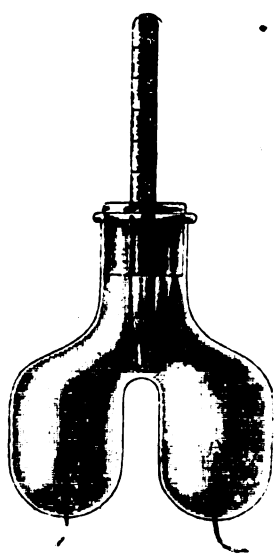
The cell contains mercury as the positive electrode, amalgamated nc as the negative electrode, and as electrolyte a concentrated lution of zinc sulphate and mercuric sulphate. Its E.M.F. amounts to 1·438 volt at 15deg.,* and decreases between 10deg. and 25deg. by 0·00115 volt with an increase of temperature of 1deg.

Construction of the Cell.

The vessel used for the cell consists, as shown in the figure, of two vertical branches closed at the bottom, and joined at the top into a neck closed by a ground-glass stopper. The diameter of the branches should be at least 2cm., and their length 3cm. The neck of the vessel should be 1·5cm. wide, and at least 2cm. long. Platinum wires about 0·4mm. thick are fused into the bottom of both branches.

The vessel is filled in a manner depending upon whether the cell is to be used at the place of construction or is to be transported.

In the former case pure mercury is poured into one branch, and into the other an amalgam of about 90 parts mercury and 10 parts zinc, which is fluid when hot and solidifies on cooling. The platinum wires must be completely covered by the mercury and the amalgam respectively. Upon the mercury is poured a layer of paste 1cm. deep, made by rubbing together mercuric sulphate, mercury, zinc, sulphate crystals, and concentrated solution of zinc sulphate. This paste and the amalgam are then both covered with a layer 1cm. deep of zinc sulphate crystals, and finally the whole vessel is filled with concentrated zinc sulphate solution until the stopper on being introduced just touches the surface. Care should however be taken that the vessel contains a small air-bubble, since that prevents its bursting in the case of a great rise of temperature. At the final closing of the vessel the glass stopper is brushed over at its upper edge with shellac dissolved in alcohol and then firmly inserted.



If the cell is to be sent away, a circular electrolytically-amalgamated piece of platinum foil, about 1cm. long and 0·1mm. thick, takes the place of the mercury, and is firmly attached to the platinum wire introduced through the bottom. Zinc amalgam forms, as before, the negative electrode, and is covered with a layer of zinc sulphate crystals 1cm. deep. The rest of the vessel is filled up to the stopper with mercuric sulphate paste. The final closing is effected as already described.

Preparation of the Materials to be Used in the Cell.

Mercury.—All mercury to be used in the cell should be purified by the ordinary processes, and distilled *in vacuo*.

Zinc.—The commercial pure zinc may be used straight away. To prepare the amalgam, add one part zinc to nine parts mercury, and keep both in a porcelain dish at 100deg., stirring gently until the zinc is completely dissolved in the mercury.

Sulphate.—Before use test the commercial zinc sulphate for acid with litmus and for iron with potassium sulpho-cyanide. If it is sufficiently pure it may be at once re-crystallised in the way detailed below. If it contains appreciable traces of free acid, equal parts of the zinc sulphate and distilled water are boiled with zinc filings in a suitably formed porcelain dish until no further gas is given off at the zinc, and the solution shows after cooling a white, or, in the presence of ferric hydrate, a brownish precipitate of zinc hydrate. If the solution was free from iron it may be filtered off after standing for two days. Otherwise it is again heated to 60 or 80, and

* Communicated to the *Zeitschrift für Instrumentenkunde* by the Physikalisch-Technische Reichsanstalt. In connection with the subject matter of this Paper, see also Dr. Lindeck, *Zeitschrift für Instrumentenkunde*, January, 1892; Rayleigh, *Phil. Trans.*, 175, p. 411, 1884, and 176, p. 781 1885; and J. Swinburne, *The Electrician*, September 4, 1891.—*Tr.*

* This number rests on the supposition that 1 ohm = 1·06 Siemens unit, and that a current of 1 ampere deposits in one hour 4·025 grains silver from an aqueous solution of silver nitrate. It is to be taken as provisional, and can only be regarded as final when the pending work on the practical units of electrical resistance and atrength of current is finished.

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electrolysed for six hours by a current not exceeding 0·2 amperes introduced by two pieces of platinum foil of about 50 sq. cm. surface suspended in the liquid. The liquid having cooled over night, litmus is again employed to test whether any acid has been formed during electrolysis. In that case the boiling with zinc filings must be repeated, and the solution again electrolysed by weak currents. During this whole treatment care has to be taken that the concentration of the solution remains approximately constant. It is, therefore, well to cover the vessel containing the solution with a glass plate, so that but little water vapour can escape. As soon as the solution is sufficiently free from acid and iron it is filtered off. To each litre of the filtrate about 50gr. of mercuric sulphate, free from acid, are added and well stirred. The mercury salt will in general assume a yellow colour after long standing. If the solution has stood for a day, and a portion of it, on being shaken up with more mercuric sulphate, does not turn perceptibly yellow, the solution may be filtered off and concentrated in a flat porcelain dish over a water bath. Here we must take care that the crystals do not form at too high a temperature, as otherwise they easily lose a portion of their water of crystallisation. To secure this the flame under the water-bath is extinguished, and the dish left in position covered with a glass plate. If after further cooling no crystals are separated, further concentration is necessary. If the heating was too protracted, and the crystals were formed under unfavourable conditions, a little water must be added and the whole warmed until everything is redissolved. The concentrated solution is poured off, and either further evaporated or kept for future use. The last traces of the solution are removed from the crystals by letting the dish stand for some time in a slanting position. It it is not advisable to sharply dry the crystals, as they thereby lose water of crystallisation. For the same reason they must be kept in a closed vessel.

Sulphate of Mercury.—The mercuric sulphate used must not be coloured yellow by a basic salt. If that should be the case, stir up one part of the salt with two parts distilled water, and add, constantly stirring, so much of a solution of one part mercuric sulphate to 1,000 parts of water as is necessary to make the colour disappear. Then pour off the liquid and wash the paste several times with distilled water, but without thereby causing another yellow colouration. If the sulphate is white to begin with, and only shows a faint yellow colouration after considerable time on shaking up with distilled water, it may be used at once. If this colouration is not shown on shaking up with water, the salt must be washed out several times with distilled water until the first traces of yellow colouration appear. If the salt had to be wetted for cleaning, the water should be driven off as much as possible by mechanical means. If dried by heat the yellow colouration will reappear. In order not to have to keep the wet salt only so much salt should be treated by the above process as is necessary for the purpose in hand.

To prepare the paste, two parts of the sulphate should be added to one part of mercury. If the sulphate was dry, it should be stirred up with a paste made of zinc sulphate crystals and concentrated zinc sulphate solution until the whole forms a stiff mass everywhere permeated by zinc sulphate crystals and small globules of mercury. But if the sulphate was wet, only zinc sulphate crystals should be added, taking care, however, that they are in excess, and are not dissolved even after prolonged standing. Here, also, the mercury must permeate the paste in small globules. It is well to crush the zinc sulphate crystals a little before using, so that the paste may be more easily manipulated later on.

Details of Construction.

For the preparation of cells containing mercury as the positive electrode, the following details should be attended to :—Before introducing the hot zinc amalgam place the glass vessel, well cleaned and carefully dried, into a hot water bath. Then pass a suitable thin-walled glass tube through the neck of the vessel on to the bottom of the branch which is to contain the amalgam. The tube ought to be as wide as is consistent with the dimensions of the vessel. It is intended to protect the rest of the vessel from contamination. The amalgam is introduced by means of a glass tube about 10cm. long drawn out into a point, the other end being provided with an indiarubber tube about 3cm. long closed by a short glass rod. The point of the tube is inserted below the surface of the liquid amalgam heated in a dish, and a portion of the amalgam is sucked into the tube by compressing and releasing the indiarubber. The point is then quickly freed from external impurities derived from the surface of the amalgam, introduced into the cell through the wide tube, and emptied by pressure on the indiarubber. The point ought to be so fine that the amalgam does not issue except on pressing the rubber. The process is continued until the branch contains the required quantity of amalgam. The vessel is then taken out of the water-bath. After cooling the amalgam should adhere firmly to the bottom of the vessel and exhibit a bright metallic surface.

To introduce the mercury and the paste a suitable funnel with a long tube is used. The paste should not touch the upper walls of the vessel, but may be pushed in with a glass rod if too stiff to flow.

Before pouring in the zinc sulphate solution the paste and zinc amalgam should be covered with zinc sulphate crystals, these prevent a creeping up of the paste after wetting with solution. In filling, the zinc sulphate crystals and the liquid should not contain large air-bubbles. These may be removed by knocking.

If the cell is to contain amalgamated platinum foil as the positive electrode, the amalgamation may be performed as follows:—The cell vessel is first filled with aqua regia and heated in a sand-bath until a rapid development of gas takes place at the platinum. Then rinse with water, pour mercury into the branch intended to contain the zinc amalgam, and fill the entire vessel with a concentrated solution of mercurous nitrate containing a little nitric acid. Then connect the mercury with the positive and the platinum foil with the negative pole of a battery, and send a current of about 0·5 ampere through the solution until the platinum foil is covered over with firmly-attached mercury globules. The whole process lasts about five minutes. Finally the vessel is thoroughly rinsed with distilled water until not a trace of the nitrate remains.

The zinc amalgam is introduced with the precautions mentioned. After cooling, it is covered with zinc sulphate crystals, to which concentrated zinc sulphate is added after filling until the whole forms a paste. The vessel is let stand for two days, so that the crystals are closed up and form a layer impervious to the paste. Then the whole vessel is filled up with the latter.

The following points should be specially borne in mind in the construction :—

1. The mercury intended to serve as positive electrode must be kept rigidly free from contamination by more positive metals. Special care should be taken that no portion of the zinc amalgam comes into contact with the mercury.

2. The cell should always be so arranged that at all temperatures the whole electrically active surface of the electrodes is in contact with zinc sulphate solution concentrated for the temperature in question. Hence during the process of filling crystals should be added in such quantity as to ensure their presence in excess even at the highest temperatures which the cell may attain.

3. The zinc sulphate used must not contain free acid. For in the thing the E.M.F. of the cell is affected by it, and, on the other hand, the circuit of the cell may be broken by hydrogen developed at the zinc. For the gas produced cannot escape through the zinc sulphate crystals, but collects underneath them, and finally pushes them up, thereby interrupting the connection between the zinc and the zinc sulphate.

For easy and safe handling the cell is attached to a metal case which may be closed and placed in a petroleum bath. Its lid is provided with two binding screws, each of which is joined to one of the electrodes ; the bottom is perforated, so that the cell is surrounded by the petroleum. To determine the temperature of the cell, a thermometer must be enclosed in the case whose scale can be read from outside. The best plan is to fuse a thermometer into the glass stopper, as shown in the figure, so that the bulb penetrates as far as possible into the cell and the scale projects through the lid.

Cells of this pattern are being constructed by Herr R. Fuess in Steglitz, near Berlin, and may be tested and certified at the Reichsanstalt at the option of purchasers.

PARLIAMENTARY INTELLIGENCE.

ELECTRIC POWERS PROTECTION CLAUSES.

TUESDAY, JUNE 27TH.

Mr. PEMBER addressed the Committee on behalf of the National Telephone Company, urging that in the future there might be very many uses to which slight electrical currents with earth returns could advantageously be put, but at present there were only two : the telegraphs and the telephones. He dwelt upon the importance and the extent of the telephone service, with its 218 million messages, and said that if the tremendous incubus of expense of doubling the wires was put upon the Company the price of telephony to the public must be increased, while in the public interest the additional overhead wires would be disadvantageous. With the telegraphs and telephones, who were the first in the field as users of the earth for electric circuits, the currents were so low as to do harm to nobody else. The telegraphs were protected by the veto of the Postmaster-General, and it was only reasonable that the telephones should also be protected. It was suggested that metallic returns were best for the telephone companies themselves, which theoretically and scientifically might be true, but there was, he contended, no marked superiority, seeing that in towns where the National Company had been in competition with the Post Office working metallic returns they had been able to increase their business. The metallic circuit system could only be adopted if they were let alone and without disturbance. The suggestion was also made that the telephone clauses had checked the growth of electric traction in

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England, and so deprived the public of the benefit to be derived from it. Even if that were true he should still urge that the clauses should be upheld. They had in the telephones and the electric traction two very great benefits to the public, of which, he suggested, the telephones were not now, and would not be in the future, by any means the slighter of the two; and he should say that it was not right to oust one set of undertakers for another when those to be ousted were prior in time, and had the legal theory of innocuous user so completely on their side. But he maintained that the clauses had not deprived the public of the benefits of electric traction, inasmuch as there were 70 cases in which tramway companies or corporations had power to work by electricity, but had not adopted it. It would not make the rate of traction cheaper, or progression speedier. The advocates of electric traction contended that they could not completely insulate. To that his answer was that they had better go and learn how. Far greater difficulties in connection with electricity had been overcome by science, and he advised them to go and overcome that difficulty, together with their present inability to do without the hideous disfigurement of the overhead trolly, for he maintained that they would not be allowed to use electrical traction in England on any great scale until they had got rid of the latter difficulty, and ought not to be allowed to use it until they had got rid of the first difficulty. All the difficulties in the way of underground tramway communication could be got over as they had been done at Buda Pesth, and after all that science had done it was simply ridiculous to suppose that she was going to be beaten by mud and damp and falling nails. The traction companies wanted, as Major Cardew had suggested, a little mild compulsion, and that compulsion should be in the form of saying that they should not use the earth for those currents, and thereby hurt other persons. If they were not forced to make the necessary improvements they would not do so, and would go on to the end of the chapter and say that they could not. The policy of Parliament had been the right one hitherto of placing restriction both upon electric lighting companies and tramways; the Government, by its veto, could take care of the Post Office telegraphs and telephones, and he asked that Parliament should continue its protection to the National Telephone Company. As to what should be done in the way of legislation the telephone companies would be quite content with the continued insertion in all tramway Acts of the Plymouth Clause. He could not, however, shut his eyes to the fact that the Committee might interpret their instruction to mean much more than a declaration of what ought to be done between existing parties. They might think that in future there might be a dozen or a hundred uses of which as yet nothing was known to which delicate currents with earth returns might be put, and it might be wise to safeguard those by general legislation on the ground that prevention is better than cure. It might therefore be done by enacting that in no case should a current be sent to earth, never mind who by, greater than some ascertained fraction of an ampere; and as to what the limit should be there would, of course, be scientific evidence taken as to the point at which currents harmful to others might be said to begin. That, however, would not cure induction, and for that purpose it might be enacted that the two wires should be laid so near as to prevent induction. To meet the difficulty of insulation not being absolutely practically perfect, he suggested that the principle of the clause which compelled railways to consume their own smoke should be followed, providing that it should be a sufficient compliance with the Act if the promoters in the construction and maintenance of their works and the working of the tramway from time to time adopt the best known means of insulating the conductor and other electrical works to prevent injurious interference by induction or otherwise with other electrical circuits.

Mr. MOULTON (on behalf of the Railway Companies) said that in the course of electric lighting legislation the companies had been placed under terms which entailed upon them a greater task than the traction companies had of conducting their operations so as not to injure others. The change of front on the part of the traction companies did not mean that electricity had grown more timorous or more weak. It was a struggle not on behalf of electricity generally, but on the part of one rich interest to extend in England an imperfect, early, and undeveloped system, which would give more trouble to get rid of than it would do good so long as it lasted. They asked for the indulgence of being allowed to use currents of very great intensity and magnitude, being the output of engines of many hundreds of horse-power taking no precaution to prevent leakage to earth; on the contrary, using that leakage as a means of assisting the return of their current, thereby throwing serious damage and responsibility on all their neighbours. The reason they asked to do that was that they might extend a cheap system of traction of the very earliest and crudest form, and if they were allowed to do it it would have the result of keeping all better systems out of the market for all time. The double insulated return, he maintained, would not throw a large extra expenditure upon the traction companies. As to the question whether they would be able to bridge over the gap of 14ft. with the underground conductors, he did not believe a single engineer who had been called who, if offered a premium of £500, would not be able to think out something to get over that difficulty. The only system which asked for the indulgence was the single overhead trolly system; but that was not the only form of traction existing. The best system in England was that at Birmingham, where they used accumulators on the car and ran without interfering with anybody. He did not see why the single-trolly system should be allowed to compete on unfair terms with other systems which worked without damage to anyone. Electric traction did not need the indulgence asked for, either by accumulators or by the double system underground or above ground; it could be done without. We had not yet exhausted invention, and he knew many methods which had been suggested which would have a chance if the cheap and nasty system of single overhead wires was not permitted. He dwelt at length upon the inconveniences and dangers to which the railway working was exposed at present, and urged that the cost of preventing those dangers, so far as they could be prevented should not fall upon the railway companies. He asked that which had been given in the Bolton case should be given as a regular thing, viz., that the promoters should so construct and maintain their electric circuits and so work their tramways in all respects as to prevent any injurious effect by leakage or induction with the railways signals and telephonic apparatus; and that before electricity was used on any tramway the Board of Trade should certify whether any and what works or appliances were required on the Railway Company's premises, for the purpose of preventing any interference; the Railway Company to execute such works, and the cost of executing and maintaining them should be paid by the promoters. They also asked for a further clause, "If in the construction working, use, or maintenance of said tramways or other works of the promoters, the telegraphic communication is interfered with, the Railway Company may execute and maintain such needful and proper works as may be reasonably necessary for remedying or obviating the disturbance, and the promoters should afford to the authorised officer of such railway company all reasonable information and facilities for the purpose of enabling them to ascertain the cause of such interference and disturbance." Then there was a proviso at the end, "Nothing in this Act shall exonerate the promoters from any action, indictment, or proceedings for nuisance in the event of any nuisance committed by them in the exercise of any powers for the use of electricity conferred upon them by this Act." Those were the clauses which he asked the Committee to insert for the benefit and protection of the railway companies.

Mr. BALFOUR BROWNE then addressed the Committee on behalf of Municipal Corporations in England and Scotland, 12 of which he said he represented. Those corporations owned something like £2,000,000 worth of tramways, and even where they were not at present the owners they could become so by purchase. In all the interest of the tramways were represented by 15 million solid sovereigns, whereas the telephones represented only 3½ millions, not of solid sovereigns, but a great many of them paper sovereigns. The Telephone Company spoke of their 218 millions of messages, but against that there were the 500 millions of passengers by tramways. Therefore he urged that tramway traction was of far more importance to the public than the telephones, and that the telephone clauses really stood in the way of electric traction. He referred to the experience of Salford, Birmingham, and Glasgow. The Committee would have to choose between the two, for Mr. Sinclair had declared that the continuance of the telephones debarred any increase of electric traction. If it were a question between telephones and tramways, he urged that the people would choose the tramways, and characterised the use of telephones as the luxury of people who wanted to indulge their idle hours by hearing other people's conversation. The telephones, even without tram traction, would have to adopt metallic returns for their own protection. The exchanges at Johannesburg and Pretoria had metallic returns, and were in advance of England; the exchanges which the Government were putting up in India were all metallic returns; the exchanges in Australia, put up on the single-wire system, were in all the large towns being changed into metallic returns, while the Government had declared that in future they would not grant any licenses for telephones unless they had metallic returns. The fact was that the telephones were not complete or perfect until they had a metallic circuit, and whatever the tramway companies might do it would be impossible practically to insulate so as not to interfere with the telephones.

THURSDAY, JUNE 27TH.

With regard to the railways, Mr. LANGDON thought that even if there was no electric disturbance at all from the tramways there ought to be a metallic return on the railway signals. And he said, "That is the advice that I would give to my Company." What did he want to insulate the tramways for? merely to give him what they called a second line of defence. This second line of defence which they desired at an enormous expense to the tramway companies was absolutely unnecessary so long as their insulation continued perfect. Passing from the railways to the question of the electrolytic action on pipes: the whole of this arose from an unguarded, and perhaps the only unguarded, expression used by Mr. Preece. It was all nonsense; the electrolytic action did not exist. The water companies and the gas companies knew quite well about this inquiry, and they did not ask to be heard before the Courts at all until Mr. Preece said that he thought the question of electrolytic action on water pipes was serious. Mr. Hesketh said "We have had reason during the past month to take up all the main streets of Blackpool for the purpose of laying down electric lighting conduits, and in no instance have I seen any evidence of electrolytic action, although I paid particular attention to the matter." The one case of electrolytic action that was quoted against them was the case of Preston, and was disposed of by Major Cardew. Under these circumstances was there anything in that electrolytic action case. This was not a question of electric traction against all the world, it was a question of the telephone against the world. The remedy was obvious; to get efficient telephones they must have metallic circuits.

Mr. CRIPPS then addressed the Committee on behalf of the Traction Companies. Their desire would be to give what assistance they could towards formulating such a clause that all parties might be reasonably protected. He should like to say a word about a misapprehension that seemed to have arisen. Talking of the traction companies, they had never used the earth return, and did not desire to use the earth return. The question was not between the earth return and the metallic return, but it was a question really between the insulated and uninsulated metallic return. And this was really carrying out Mr. Preece's suggestion. The clause they proposed was: "The Company (that was the traction company) shall use metallic returns," therefore there was an obligation in their form of clause upon the traction companies to use the metallic return as contrasted with earth return, "and in working their system shall take such reasonable precautions as the Board of Trade may direct for preventing interference with any properly constructed insulated metallic circuit of any railway or telephone company, and for preventing electrolytic action

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on gas or water pipes." The basis of their clause was that railway and telephone companies should use a properly constructed insulated metallic circuit, but if they did, their subject to the directions of the Board of Trade to work their system under such conditions that they did not interfere either with the railway system or with the telephone system, and also under such conditions as to prevent any electrolytic action on gas or water pipes. They did not believe there was the least difficulty as regarded the electrolytic action on gas and water companies. They were willing to come under the obligations to follow any directions required by the Board of Trade to prevent electrolytic action on gas or water pipes. What they desired to see, and that was the intention of the clause, was a proper protection as between parties seeking for special statutory powers in relation to these great public objects. Mr. Preece and all the other witnesses had stated the same, stated that the best system of telephonic communication was the metallic circuit return; that was the proper remedy, and that was the remedy for which the clause provided. If the committee were to come to the conclusion that the telephone system or the railway signalling apparatus was not to be insulated, there was an end to traction. The telephone companies objected that there would be great interference in changing from the earth-return system to the metallic-return system. The complete and absolute answer to that was that they were doing it in London. There was no traction company interfering with them in London, and yet for their own purposes, throughout the whole of the London district—500 square miles Mr. Gaine had told them—they were substituting the metallic-circuit returns for the earth-return system. And then on the question of expense, they knew that the National Telephone Company had a metallic-circuit return in Hull and Newcastle, where a subscriber was charged £10 a year. In London, where they had the earth-return system, admittedly not the best, the charge was from £17 to £20, and they were bound, apart altogether from the question of traction companies, to introduce the better system.

Mr. POPE then addressed the Committee on behalf of the Gas and Water Companies. He said the clause proposed by Mr. Cripps might be paraphrased thus:—"That this Committee recommends that the Traction Company do what they are doing, and that the question of what restriction is to be imposed upon them should be referred back to the Board of Trade," and he could not help thinking that it was an ingenious method of tempting the Committee to give practically no clause at all. He would ask them definitely to recommend that in all future grants of statutory powers to use electricity insulated metallic returns should be required as a condition of that user. He maintained that the dangers from electrolytic action and corrosion were very serious, and submitted the following clauses to the Committee:—

"(A) The undertakers shall not make use of, or permit to be used, any conductor other than an effectively insulated conductor for carrying any supply of electricity from or to the generating station; nor shall they in any manner connect, or permit to be connected, to earth any part of any circuit except for the purpose of testing or indicating.

"(B) The undertakers shall employ all practicable means for preventing, detecting, and, as soon as practicable, stopping any leakage of the electric current to earth.

"(C) The undertakers shall not use or employ, or permit to be used or employed, any gas or water mains or pipes as conductors, for the purpose of completing any electric circuit or for the conveyance of electric current.*

"(D) Nothing in this Order contained shall prevent the undertakers from being liable to an indictment for nuisance, or to any other legal proceeding to which they may be liable in consequence of generating, using, or supplying electric currents.

"(E) The undertakers shall compensate every person who suffers any damage by reason of any failure to observe the provisions of this Order, or caused, without any default on his part or on the part of persons for whom he is responsible, by an electric current generated, transmitted, or employed by the undertakers."

Mr. WALLACE (on behalf of the Electric Lighting Companies) asked the Committee to exempt the Electric Lighting Acts altogether from any operation of any clauses that the Committee might require to be inserted in any general Bill. The position of the electric lighting companies had been definitely settled. There was a Committee in 1882; there were the Electric Lighting Acts of 1882 and 1888; and the very extensive inquiry held by Major Marindin, in which the nature of the supply of electricity that was to be allowed to the electric lighting companies was thoroughly gone into and settled once for all.

The CHAIRMAN said the Committee would meet again to discuss the matter, and, if necessary, would communicate with Mr. Wallace, and he should have the right of appearing.

This concluded the proceedings, and the Committee adjourned till Thursday, when they will confer in private.

* (This is copied from Section 29 of the Gasworks Clauses Act, 1847.)

Uni-Directional Currents Obtained from Alternating Currents.—An attempt to obtain a commercial solution of this important problem, satisfactory enough to enable the rectified current to charge a storage battery, has been made by M. Pollak, who has communicated his results to the Académie des Sciences. M. Pollak uses a synchronised commutator in conjunction with an interrupting device for preventing discharge from the storage battery when the rectified voltage falls below that of the battery.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June* 23, 1893.

Small Central Stations.—Attention is being directed to the fact that small central lighting stations in the United States with very few exceptions are financial failures. Several reasons have been advanced to account for this, but it is doubtful if even the most favourable conditions would put the majority on a paying basis. The truth of the matter seems to be that in the earlier days of electric lighting the popular craze for electrical speculation, united with the American desire to be up with the times, rendered the specious claims of selling agents irresistible, and apparatus was bought and stations erected with scarcely any argument in favour beyond the all-powerful one that "electricity is the coming thing." Several syndicates have been formed which are purchasing non-paying stations for but a small percentage of the original cost, thoroughly over-hauling them, and, by placing them on a thorough engineering and business basis, are earning good dividends on their investment. In a few years we may expect the same unsatisfactory state of affairs in regard to the hundreds of electric railways now being built with no real prospects of financial success.

A New Conduit Electric Railway System.—An experimental conduit electric railway is being exhibited at Coney Island, the summer resort near New York. A flexible shoe 7ft. 6in. long, secured underneath the car, enters through a slot into a conduit. At intervals of about 6ft. in the conduit are boxes, from which project an arm at right angles; when the shoe strikes the arm, the latter is moved forward, and by means of a brush inside the box makes connection with the supply line, the current passing to the metallic side of the shoe by means of sliding contact with the end of the arm. The boxes containing the contact brush and mechanism are filled with a liquid insulator and so designed as to avoid leakage, even if the conduit should be flooded. The only connection with the supply line at any one time is through the two boxes opposite the shoe, and it is claimed that leakage is thus reduced to a minimum, the insulation in all of the other boxes being practically perfect. The shoe is flexible and easily admits of going around sharp curves, and is automatically released from the car if the latter should be derailed.

The Electrical Fountains at the World's Fair.—It is reported that the electrical fountains at the World's Fair are far from being successful.

CORRESPONDENCE.

CONTINUOUS CONTROL OF ELECTRIC LIGHT CABLE SYSTEMS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I take the liberty to inform you that the remarks Dr. Kallmann published in No. 784 of your esteemed journal on my methods of finding faults in the network of central stations during the working of the plant do not agree with the facts.

Dr. Kallmann says: "In admitting that his methods are useless, if the middle wire be earthed at any point, Dr. Frölich has shown the inapplicability of his plan to nearly all central-station networks, as in nearly all cases the insulation of one pole is more or less negligible."

First, it is to be answered, that my methods, in the form published in your journal February 10th, 17th, 24th, 1893, are still very easily applicable when the insulation is very low; for instance, about one ohm. Whereof, these methods are directly applicable to all central stations whose middle wire is not really earthed, *i.e.*, to most cases of central stations at large.

If the middle wire is really earthed, it is true these methods are not directly applicable; but they can be made so by a very simple contrivance, viz., by *placing the system of testing or pilot wires instead of earth* in the diagrams of my methods. Hence, my methods of taking insulation and finding faults extend to all parts of the network where testing wires are laid, even when the middle wire is really earthed.

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Dr. Kallmann's methods are applicable only as far as testing wires are laid. Now, in all cases I know of, testing wires are not introduced into the houses, but are laid with the street cables only. Now, most faults happen to occur in houses, and just these faults are not detected by Dr. Kallmann's signals. My methods show faults even in the houses, when the middle wire is not really earthed. If the latter is entirely earthed, it will probably be impossible to find faults in the houses by any measurement, and that will be the reason, I think, why, in this case, testing wires *must* be introduced into the houses.

Dr. Kallmann remarks that my methods "entail the expenditure of much time and material." In saying so he omitted to state that, after my methods, all necessary measurements can be taken by the telephone, viz., by the very simplest instrument.

It is true that it is easier and takes less time to observe the automatic signals of Dr. Kallmann, instead of applying my methods. However, faults are only detected by Dr. Kallmann's signals when they are obnoxious to the plant itself, or to neighbouring plants, while my methods allow a daily survey to be taken over the insulation in all parts, and to determine faults long before they grow obnoxious.

In concluding, I beg to remark that Dr. Kallmann's signals do not show faults when they have already spoiled the telephonic intercourse in the neighbourhood, earth being used in the telephonic circuit; for it has been stated several times by officers of the Berlin Telephone Service that in case faults arise suddenly in the central station, hundreds of telephone annunciators fell, while Dr. Kallman's signals remained untouched.—Yours, &c.,

Berlin, June 21, 1893. O. Frölich.

SINGLE-PHASE ALTERNATE-CURRENT MOTORS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The course which has recently been taken by the controversy as to the priority in the field of single-phase motor construction induces us to send you the following statements, hoping that you will give them publicity in your columns.

After the publication of a description of his new alternate-current motor, by Mr. C. E. L. Brown, Herr von Dolivo-Dobrovolsky tried to show that such motors were entirely useless in practice. While Herr Arnold, of the Maschinenfabrik, Oerlikon asserted that the motor of Mr. Brown was nothing new at all, but had been known for years.

Now, since both of these assertions have been discredited, Herr Behn-Eschenburg, also of the Maschinenfabrik Oerlikon, discovers that he himself invented this motor (which, according to Arnold, had long been known) *as early as the summer of 1892*, and that Brown has simply copied it.

The following lines will, however, set right these assertions in a very simple manner:—If Herr Behn-Eschenburg were acquainted with the tests carried out in Oerlikon he would know that as early as 1890 and 1891 Brown had already ascertained, in the course of his experiment, that multiphase motors may be ran and even started with only two phases just as well as with three. He also showed that multiphase motors when once started continue to run with one phase only, although in consequence of their not being designed for it they gave but little power. Nevertheless, the present alternate-current motor of Brown may be said to have been invented in these experiments.

After the founding of this firm, we took up energetically the further development of these observations. *In October, 1891*, we received from Herr Oscar von Miller inquiries for the electrical station at Furstenfeldbrück. This had been intended by Herr von Miller to be on the rotating current system; we tendered for the supply of alternate current, since we declared ourselves in readiness to supply alternate-current motors as good as those for rotating current "which will start themselves, and possessing neither collectors nor sliding contacts." In answer to a question from Herr von Miller as to how the motors were started, we wrote to him, "the starting is effected without commutation of the current by artificially-produced difference of phase." At the same time we sent to Herr von Miller a drawing of such a motor showing Brown's short-circuited rotating part exactly as he constructed it in his multiphase motors.

On November 27, 1891, we sent in our proposals for the electrical station in the town of Chur, for which installation we similarly proposed simple alternate current on the grounds "that we have succeeded in constructing electric motors for ordinary alternate currents which compare equally with those for direct current as well as those for multiphase alternate current." In the description of the motors the proposal runs as follows:—"We supply electric motors for alternate current, which have the peculiarity that they possess neither collectors, brushes, nor sliding contacts." Almost the same sentence is to be found in our tender for Ragaz, dated February 2, 1892. For all these stations the Maschinenfabrik Oerlikon had tendered rotating-current systems, and it is principally to be ascribed to our proposals that they were carried out with alternate current.

Herr Oscar von Miller in January, and the promoters of the Ragaz station in February, 1892, had seen such a motor at our works. In the following months such motors were shown by us to a great number of visitors to our works, among whom were many very prominent electricians.

All this is not affected by the circumstance that in the summer of 1892 we had also taken up the construction of synchronous motors for the same reason which appears to still prejudice Herr Behn-Eschenburg against the non-synchronous type. We hoped by the use of synchronous motors to reduce the idle current. Our experience shows us, however, that this desirable result cannot, under the conditions which obtain in practice, be attained with this type of motor, while we have succeeded in so improving the non-synchronous motors that their idle current is remarkably small and that they will start with a moderate increase of current.

From the above it will be readily seen that Mr. Brown did not wait for Herr Behn-Eschenburg, nor till the summer of 1892. We will therefore leave it to the reader to judge of the accusation brought by him against Mr. Brown.

We hope you will find room in your columns to give publicity to these statements.—Yours, &c.,

June 30, 1893. Brown, Boveri, and Co.

ROTATING FIELDS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I observe that in your editorial note on page 56 of your issue of May 19th, you trace the rotating field to the well-known Ayrton-Perry motor. So far as my memory serves, this motor was brought out in 1882 or 1883; but the rotating field is really much older. The motors of Bürgin and of Borel, shown at the Paris Exibition of 1881, were really rotating field motors, and so were the old Froment motors designed a quarter of a century ago, or thereabouts, and used largely for the rotation of Geissler tubes.

The invention of these rotating field motors was generally ascribed to observation of the deflection of the galvanometer needle. It was observed that by making the needle heavy and passing a momentary current through the coil constituting the field, the needle might be deflected more than half a revolution. Then by reversing the current, or, in other words, rotating the field through an angular distance of 180deg., the needle could be deflected through another half-revolution, and so on, a continuous rotation being produced. In some of Froment's motors the field was rotated in this manner through widely differing angles at a time—120deg., 90deg., 60deg., and even less in some cases, according to the number of coils. Hence we had a crop of such moters, mostly with wireless armatures differing but little from the galvanometer needle, except in being heavier and thicker and, as a rule, with extended pole-pieces. A large number of the electric secondary clocks produced during the last 20 years, have had motors of this type with which to drive the working parts.—Yours, &c.,

Chicago, U.S.A., June 18, 1893. J. G. Lorrain.

SUBMARINE CABLES TRUST.—Notice is given that on and after tne 14th inst., the sum of £1. 10s., balance of the coupon due April 15th last, will be paid by Messrs. Glyn, Mills and Co., 67, Lombard-street, E.C. The coupons should be left three clear days for examination.

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TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1893 Edition of "THE ELECTRICIAN" Electrical Trades' Directory and Handbook is NOW READY. This useful book contains over 1,000 pages, and several new and handy features have been added. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

TENDERS INVITED.—The Directors of the Electricity Supply Company for Spain (Limited), invite tenders for the supply and erection of machinery, &c., required for the extension of their works in Madrid. Further particulars appear in our advertisement columns, and plans, statement of requirements, &c., may be obtained at the offices of the Company, 15, St. Helen's-place, on and after Monday next, 10th inst. Tenders must reach the Secretary, Mr. P. A. Latham, before 11 a.m., on July 29th.

——— The Secretary of State for War invites tenders for the purchase of a quantity of old metal. Tenders have to be in to the War Office by 12 o'clock noon on Wednesday, the 10th inst., addressed to the Director of Army Contracts.

——— The Municipal authorities of Ostend invite public tenders for the electric lighting of the town, which must be in by September 15th.

——— The Corporation of Launceston (Tasmania) invite tenders for the supply and erection of electric lighting plant, and for the maintenance and working of the installation for six consecutive months. Tenders are to be in byDecember 30th next.

——— The Electric Lighting Committee of the Lancaster Corporation invite tenders for the erection of a brick chimney, 120ft. high, to be built in the Corporation yard, Maston-street. Tenders must be in by the 15th inst.

TENDERS RECEIVED.—Six tenders have been received by the Municipal authorities of Liège for the electric lighting of the town. One is sent in by MM. Van Rysselberghe and Moris (Antwerp), one by Messrs. Siemens and Halske (Berlin), one by M. J. Jaspar (Liège), and three by M. Pieper (Liège). The amounts varied from £20,000 to £52,000 for the work of installation, and the charge for the supply of current varied from 5d. to 7d. per kilowatt. The Municipal Authorities have not yet accepted any of the tenders.

——— The following were the tenders sent in for the electric lighting of the Holborn Town Hall, that of Messrs. Verity and Sons being accepted (as stated in *The Electrician* last week):—Messrs. Hulett and Co. (Limited), £585; Messrs. R. S. Hughes (Limited), £548; Messrs. Verity and Sons, £400.

——— The Paddington Baths Commissioners have received the following tenders for fitting up the baths with electric light apparatus:—Mr. Sclater, £85; Messrs. Southerley and Ridout, £72; Messrs. Dawson and Hammond (accepted), £75.

APPOINTMENTS VACANT.—The Council of the Borough of West Ham invite applications for the appointment of electrical engineer, who is to prepare plans and specifications and superintend the work of the installation to be carried out in the borough, and to advise the Council generally on electrical subjects. The salary would be £250 per annum, and applications must be in by five o'clock on Monday, July 17th, to Mr. Fred. E. Hilleary, the Town Clerk, Town Hall, West Ham.

——— Mr. J. C. Sharman, Assistant Electrical Inspector at Liverpool, having resigned his position, the Electrical Sub-Committee of the Corporation Watch Committee have been instructed to take steps to fill the vacancy.

REMOVAL NOTICE.—Mr. T. Harding Churton, of Leeds, has removed his works and stores from South-parade to Park Cross-street, Leeds. The office address is still 5, South-parade.

MESSRS. J. AND W. WEEMS.—This firm have opened an office in London at 22, Billiter-street, E.C.

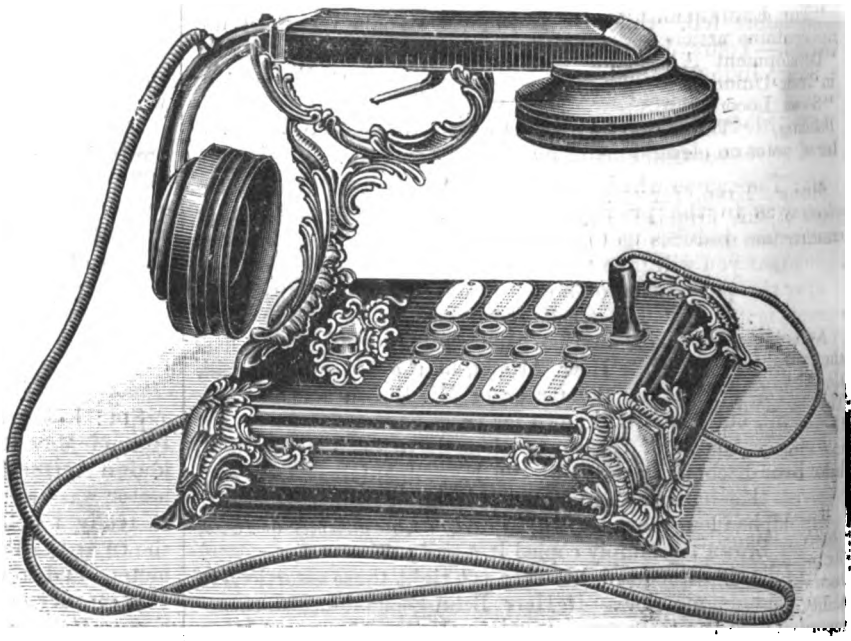
DISSOLUTION OF PARTNERSHIP.—Messrs. Appleton, Burbey, and Williamson, electrical egineers, have dissolved partnership. Debts will be paid by Messrs. W. T. Burbey, A. E. Williamson, and E. L. Joseph, who continue the business.

AUCTION BIDS BY TELEPHONE.—An instance of the commercial usefulness of the telephone was recently shown in Liverpool, where the bidding at an auction of some building society shares was carried on between some gentlemen present and a telephone subscriber, who was made acquainted with the rival offers through the auctioneer's instrument, and eventually secured the shares.

NOTTINGHAM EXHIBITION.—Firms desirous of securing advertisement space in the official catalogue of this Exhibition are requested to communicate with Messrs. R. Allen and Son (Limited), Caxton Works, Nottingham. The Exhibition is organised in honour of the British Association Meeting.

ELECTRICITY IN MINING.—At the meeting last week of the Tolima Mining Company (Limited), the Chairman mentioned that the installation of the electric light had greatly added to the returns by enabling more work to be done. The surface and engine works, and the underground work, as far as the bottom level, are lighted by electricity, and the various departments are in telephonic communication with each other.

COMBINED TABLE TELEPHONE AND SWITCH.—We illustrate herewith a compactly arranged table telephone and switch, which has been designed by Herren F. Butzke and Co., of Berlin. The illustration shows the simple manner in which communication can be held with different branches of an office or a factory by placing



the movable connection over the particular orifice required. The bell is not shown, being on the under part of the stand, beneath the push. The stand is made of walnut, with metal fittings, and the whole forms an ornamental adjunct to the table, and takes up but little space.

BIRMINGHAM TELEGRAPH FACTORY (LIMITED).—On Thursday Judge Chalmers delivered judgment at the Birmingham County Court with respect to the petition for the compulsory winding-up of this Company (in voluntary liquidation). His Honour had reserved judgment pending the consideration of the question whether some shares allotted to the Directors as nominees of Fowler, Lancaster, and Co. (Limited) made these Directors liable as contributaries to the estate of the "Factory" (*see* last week's *Electrician*). His Honour decided that the shares in question had been paid for in cash within the meaning of the Act, and that being so there was nothing to be gained by a compulsory order, which would greatly increase the costs, and the petition (which was presented by Messrs. H. Alabaster, Gatehouse, and Co., of London) would, therefore, be dismissed with costs.

HARTMANN AND BRAUN.—We have received a catalogue of the electrical instruments exhibited by this firm at Chicago A useful feature is the clear statement of the deflection of each of the many galvanometers described, in terms of the current required to give a deflection of one millimetre at one meter distance.

ELECTRIC LIGHT ILLUMINATIONS FOR THE ROYAL WEDDING.—Messrs. Berry and Harrison inform us that they have fixed a

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Brunswick Star, 8ft. 6in. in diameter, fitted with over 400 16 c.p. lamps, at the *Morning Post*, taking upwards of 200 amperes. The peaks of the star are clear lamps, the inner ring coloured amber, and the monogram "G. M." in red and green. The supply is being obtained from the Metropolitan Electric Supply Company, and the whole work has been done under three days. They have also constructed a "Prince of Wales's Feathers," and monogram "G. M." for the Hotel Windsor; this consists of over 200 clear and coloured lamps, taking about 90 amperes, the supply coming from the Westminster Supply Company.——Messrs. Frank Suter and Co. supplied the illumination for the Albemarle Hotel, Piccadilly, and for Messrs. A. and F. Pears (Limited), Oxford-street. In the former some 750 incandescent lamps were employed, and in the latter 300 incandescents and 10 arcs, the display in each case being most effective.——The Edison and Swan Company displayed at their head office, in Victoria-street, an immense radiating star, bulging to a central circle enclosing the letters "V. R." and "G. M." The star was 50ft. in circumference, and was built up of a thousand 8 c.p. incandescent lamps of various colours. The current was supplied from Deptford by the London Electric Supply Corporation by special leading wires from their mains.

Messrs. Rashleigh, Phipps, and Co.—This firm supplied for the illuminations on Thursday some unique designs in electric lighting work for a number of London houses. The firm has been very busy for some time past, and send us a list of a large number of installations carried out by them, including private houses, business premises, temporary lighting, &c., showing a total of nearly 4,000 lights. On Saturday last the *employés* of the firm held their annual holiday at Brighton.

"The Engineering Magazine."—The July issue of this magazine contains articles on the "Limits of the Natural-Gas Supply," "Development of the Modern Steam-Pump," "Weak Points in Trade-Unionism," "The International Engineering Congress," "Steam Locomotion on Common Roads," "Mechanical Aids to Building," "The Safety Car-Coupler Problem," as well as a number of notes on electrical subjects by Mr. Franklin L. Pope.

Messrs. King, Mendham, and Co.—On Saturday last the *employés* of this firm had their annual outing at Ilfracombe. The weather was most favourable, and a very enjoyable day was spent.

Aberdeen.—The Secretary for Scotland has formally sanctioned the raising by the Town Council of a loan of £20,000 for the execution of works under the Aberdeen Electric Lighting Order (1890). The Gas Committee have resolved to consult Prof. Kennedy as to the propriety of embracing the present opportunity of laying the iron tubes which would be required for street lighting, and the probable cost.

Belfast.—The Gas Committee reported at the last meeting of the City Council that they had advertised for offers of sites suitable for the erection of the electric lighting station. The replies had been referred to Prof. Kennedy for his opinion as to their suitability, and a sub-committee had been appointed to inquire and report upon those selected by him and as to the rentals thereof.

Bradford.—The Electricity Committee of the Bradford Corporation are at present considering the means of increasing their electric supply, in order to meet the growing demand for the light. They have had presented to them reports on the subject by Mr. Baynes, their own engineer, and Mr. Shoolbred, their consulting electrical engineer. Mr. Baynes points out that the three-wire system might be advantageously applied to the district in question. Mr. Shoolbred explains that he would follow the Continental practice where the five-wire and the three-wire arrangements, or, in other words, the converters, do not begin or come into operation except at the delivery end of the ordinary two-wire feeding mains.

Brighton.—The Town Council have approved the recommendation of the School of Science and Art Committee, that the school building be lighted by electricity; the work to be completed by the end of August.

Cape Town.—The Public Library at Cape Town is now lit by the electric light, and, in consequence, it will be open in the evening.

Cardiff.—On Monday the Mayor, Mr. W. E. Vaughan, J.P., laid the memorial stone of the new central station.

Dundee.—The gas fittings and standards for St. David's Church requiring renewal, it has been decided before proceeding with the work to obtain estimates as to the cost of introducing the electric light into the church.

Eastleigh (Hants.).—The Local Board have referred to their surveyor the question of the electric lighting of their new offices.

Glasgow.—At the meeting of the Town Council on Tuesday Mr. W. F. Anderson called attention to the proposed extension of the electric lighting machinery, but said he could not find that additional mains had been ordered. The Lord Provost said that the machinery originally provided was in connection with a totally different subject. It referred to the domestic lighting, which was greatly extending, and the mains in the streets were large enough to carry three times the power they had at present.

Grimsby.—It has been decided that the Public Lighting Committee shall consider the question of lighting the town by electricity, and the Borough Surveyor has been instructed to prepare estimates.

Japan.—The electric lighting of the towns of Japan is making considerable progress. Central stations at Hamamatsu, Maibashi, and Nikko have just been opened, the current in each case being generated by 2,000 volt alternating-current dynamos, and the power is supplied by Pelton water wheels. Everything connected with these installations is made in Japan.

Leeds.—The Leeds Corporation have agreed to contribute a portion of the expenses of placing before the Joint Committee of Lords and Commons evidence on the electric power protection clauses in the interests of municipal corporations.

Leicester.—A meeting of the Ratepayers' Protection Association was held on Tuesday, when a resolution in opposition to the proposed electric lighting scheme of the Corporation was carried.

London Central Markets.—The Court of Common Council on Friday adopted a report of the Central Markets Committee, recommending the acceptance of an agreement with the City of London Electric Lighting Company (Limited) for supplying electric lamps above the footways outside the markets, and for lighting and maintaining the same at an inclusive charge per annum of £598.

Madrid.—The tramway companies in Madrid have before them a scheme for changing the motive power from horses to electricity. The capital required is £400,000, which would be raised in Germany. It is proposed to work the trains for 25 years at a charge of 3½d. per kilowatt, the cars and electric plant at the end of this period to belong to the tramway companies.

Manchester.—The electric lighting department of the Corporation's Gas Committee have prepared a report for the year ended March 31st for presentation to the Council, in which they state that the station at Dickinson-street is almost complete, and they anticipate that current will be ready for consumers by August 1st.

Morley (Yorks.).—The Town Hall Committee of the Morley Corporation have decided to light the new Town Hall by electricity. It will also recommend the Corporation to appoint a special committee to report as to the advisability of obtaining powers to supply electricity for street lighting and for private consumption.

Newport (Mon.).—The Sub-Committee of the Parliamentary Committee on electric lighting has reported in favour of the adoption of the high-tension alternate-current transformer system as being generally the most suitable, and recommended the appointment of an electrical engineer to prepare plans, specifications, and estimates.

St. Pancras Vestry.—Mr. G. M. Clements, a member, has issued a memorandum containing statements in reference to the Stanhope-street central station, which Mr. Eccleston Gibb (the Vestry Clerk) characterises as "misrepresentations of the facts." After some discussion at the last meeting of the Vestry it was decided to defer the reception of the report of the Electricity and Dusting Committee until an answer had been prepared to Mr. Clements's memorandum by Mr. Gibb and Prof. Robinson. The residents and occupiers of Regent's Park-road having asked for the light, the Electricity Committee recommended that Prof. Robinson should be instructed to prepare specifications of the work, and that the Vestry should invite tenders. The estimated cost of the works was stated to be £2,650. The same Mr. Clements said there was every probability of the work costing £1,000 more than estimated, and that if they earned £602, after paying £522 for expenses and depreciation there would only be a miserable profit of £82.

Stafford.—The Corporation have decided, on the recommendation of the Electric Lighting Committee, to retain the services of Dr. John Hopkinson as electrical expert to report upon the electric lighting of the town, at an inclusive fee of 100 guineas. The Council have also decided to fit up electric bells at the house of

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each member of the fire brigade, and to connect the police office and fire station by telephone.

SUTTON (SURREY).—The Local Board have retained Mr. Ed. C. de Segundo to report upon the electric lighting scheme for Sutton, and to advise them generally.

TORQUAY.—At Tuesday's meeting of the Town Council the Electric Lighting Committee reported that Mr. W. H. Trentham had been consulted by them respecting a site for a central electric light station. Out of the eight alternative sites inspected he recommended the Bath Saloon site as the most preferable. The estimated initial outlay was £17,403, and the annual cost of maintenance £3,100; and the revenue (it was anticipated) would be, without including that from meters, motors, cooking apparatus, &c., £3,320 at 6d. per unit. The Committee recommended that the matter be proceeded with on the basis of Mr. Trentham's report, and that plans, drawings, and specifications be prepared, and that the Local Government Board be applied to for sanction to borrow £18,000, which would include the cost of obtaining a Provisional Order. The Mayor, as Chairman of the Committee, said that important information had been received since this report was drawn up, and having regard to the importance of the subject he suggested, that the matter be referred back to the Committee for further consideration—a course which was adopted.

TUNBRIDGE WELLS.—The Tunbridge Wells Ratepayers' Association last week held a meeting at the Town Hall to again consider the electric lighting scheme proposed by the Corporation, and after some discussion a resolution was carried that it was advisable that the electric lighting should be kept in the hands of the local authority, instead of the Provisional Order being handed over to a company. The Town Council, at their meeting on Wednesday, were to consider a recommendation from the Electric Lighting Committee to establish electric light works, to supply electricity for both public and private purposes, at an initial cost of £13,000.

WORCESTER.—A special meeting of the Watch Committee was held last week to consider the tenders for the electric light works for the city. A number of tenders were received; but the amounts were greater than were anticipated by the Committee. It was, therefore, resolved not to recommend the acceptance of any tender, but to make further investigations and report to a subsequent meeting.

BOOKS RECEIVED.

"Transactions of the North-East Coast Institution of Engineers and Shipbuilders." Vol. IX. Parts 6 and 7. (London: Andrew Reid and Sons.)

"Annual Catalogue of the Massachusetts Institute of Technology, 1892-93." (Boston, Mass.: H. G. Collins.)

"The Atlantic Ferry." By Arthur J. Macginnis. (London: Whittaker and Co.)

THE TRAMWAYS INSTITUTE.

The annual dinner of the Tramways Institute of Great Britain and Ireland took place at the Holborn Restaurant on the evening of the 29th ult. Mr. W. J. Carruthers-Wain, the President of the Institute, in the chair.

The CHAIRMAN, in responding to the toast of "Success to the Tramways Institute," said that the question of electric locomotion had been largely considered at the Institute's meeting that day, and they were indebted to the various readers of Papers on the subject of electric traction and electric lighting of tramcars and omnibuses.

Mr. EBBSMITH, in proposing the toast of "The Traction of the Future," said that they had the representatives of various kinds of traction with them that evening, but electricity was exceedingly largely and well represented. They had votaries of all systems of electric locomotion, viz., the conduit system, the overhead-wire system, and the accumulator system, and in regard to them all he said that each was the best "under certain conditions." He coupled with the toast the names of Messrs. Etlinger and Epstein.

Mr. ETLINGER said that in his opinion electricity was too costly, and the "old gees" had it still. If the cost of production of electricity were reduced—say, for instance, a man had water-power at his command—then it might pay; but under existing circumstances, and in face of all he had read, he was not disposed to support or advocate it, but preferred to stick to the horses.

Mr. EPSTEIN advocated at some length the driving of cars by the accumulator system, and recapitulated the figures of a Paper he had prepared in regard to the actual working of tramways by the accumulator system, from which it appeared that the Birmingham Central Tramways Company had had their line fitted with 12 sets of accumulators, which represented 12,000 cells and 10,000 plates, and up to the present moment they had done their work, to the best of his knowledge and belief, on the Birmingham Central Tramway Company's line without the least hitch, and with no necessity for repairs to a single plate out of 10,000. The service was a five-minute one, and the gradients were very steep. They had at first some difficulty, owing to the severe weather at the end of December and in January and February, which caused, according to tests, an expenditure, through the snow and frost, of power equal to 33 I.H.P. He contrasted the various systems of electric traction, and maintained that a line could be equipped and worked cheapest by the accumulator system. He had, he said, paid a recent visit to the United States, and studied the systems of electric traction there, where the ideas of the people on the subject were certainly more advanced than ours. He was of the opinion that the accumulator system was a very good one for companies that had a varying traffic, as they could have just the number of cars they wanted running, and not have to keep, as in the case of steam, extra engines with steam up in the sheds. The charges that the Company he represented fixed with the Birmingham Central Company were originally lower than they were now recognised; it be understood that the maximum that was to be taken from the accumulators was 130 amperes, but it was found on careful tests during running that as much as 170 amperes were taken, and accordingly a current of 210 amperes was afterwards supplied, and an increase of 50 per cent. on the original charge agreed to. He promised to prepare for the use of the Tramways Institute a series of estimates of the cost for the conversion of lines of varying lengths from horse or other traction to accumulator traction. He expressed the opinion that accumulators were undoubtedly "the traction of the future." Overhead wires and underground wires were, he said, a mistake, being too much above or too much below us; but accumulators were a happy middle course. He had practical experience as well as theoretical knowledge, or he would not dare make these assertions.

COMPANIES' MEETINGS AND REPORTS.

United River Plate Telephone Company (Limited).

The seventh annual ordinary general meeting of the Company was held at Winchester House, Old Broad-street, on Tuesday last, "for the purpose of receiving and adopting the report of the Directors and the accounts for the year ending March 31, 1893; and for transacting the ordinary business of the Company." Mr. J. Irving Courtenay presided.

The SECRETARY (Mr. Robert Herring) having read the notice convening the meeting,

The CHAIRMAN said: Before moving the adoption of the report and accounts I propose to make some observations and explanations on the various paragraphs and figures they contain, though it is not necessary that I should do so at the same length as on former occasions. Last year I expressed an opinion to the effect that we had seen the worst of the trouble in the Argentine Republic, and I consider that the course of events in the interval that has elapsed has confirmed that view. There have been from time to time periods of depression and of uncertainty, times when the outlook had a gloomy aspect, but the net results have been decidedly to the good, and my hope is that such will be the outcome of the future. At the moment we note an unsatisfactory feature in the rise in the gold premium. Similar fluctuations have previously taken place, but the average of the year under review was 215 premium as contrasted with an average premium of 280 the year before, and we can but trust, in spite of present appearances, for a further reduction during the current year. A perusal of the figures given in the latest official report from the British Legation in the River Plate, in which attention is called to "the enormous strides made by agriculture in the Argentine Republic during the last year," cannot fail to create confidence in the ultimate rehabilitation of the financial credit of the Republic, as well as in a comparatively speedy return of its commercial and business prosperity, provided only there be a fairly intelligent administration of the national affairs. I will now, according to my custom, take you through the figures of the balance-sheet. The receipts of the Company have increased from £98,699. 8s. at par of exchange, the amount received during the previous year, to £115,542, or nearly £17,060 increase. This is the net amount after providing for any bad payers on the list of subscribers, though these now constitute a very small proportion of our list. The expenses, you will observe, are slightly smaller; but this figure may be expected to somewhat increase, as the expenses are now at a minimum, and with the business growing as it is there will be an increase in working expenses. I am glad to say that there has been an increase in the number of subscribers of 710, against a loss the year before of 125. The working for the year actually shows a profit of a little over £7,000, but the policy of the Board is to consolidate and strengthen the position of the Company, and to that end we have dealt with this sum in a manner that I trust will meet with the approval of the shareholders. We have written off the balance of the taxes suspense account, £768. This is the balance of an item which was spread over several years, and now disappears. We have also written off for bad and doubtful debts £2,728. This amount does not arise out of the operations of the year under review, but is a balance in connection with previous sales business of the Company in the various provinces. We have transferred £3,000 to depreciation and renewal fund, leaving this amount, in accordance with our Articles

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f Association, in a form where it can be dealt with in the future s may seem most desirable; and there still remains a balance for the ar of £540 to be carried forward. The shareholders will have observed at notwithstanding the fall in the gold premium the loss on exchange is eater than it was in the previous year. The explanation of this is, that the net receipts in the Plate at par of exchange were nearly 50 per cent. ore, the loss in conversion, notwithstanding the lower gold premium, was nsiderably larger. I would point out that the loan from the bankers, 2,100, which appeared in the last balance-sheet, has been paid off. We ve reduced the amount that stood in previous balance-sheets £29,209, e cost of converting the Seven per Cent. Debentures and issue of benture stock, by the sum of £9,000, which amount was transrred from depreciation and renewal account for that purpose. I ay mention that we have just paid off the balance of the Seven r Cent. Debentures—that is, those held by the debenture holders ho declined to convert into Five per Cent. Debenture Stock. The ffect of these appropriations is to materially strengthen the Company's eneral position, and, of course, to improve the value of the Five per Cent. ebenture Stock in which so many of our shareholders are interested. An important change has been made in the administration of the Comany's affairs in the River Plate during the past year. Mr. Chappell, who was manager at Rosario, has been made the General Manager in the River Plate, while the Company retains the valuable services of Messrs. Fells and Krabbe, our former Managers, as Consulting Directors. By this arrangement we have effected a considerable economy, and we consider that it has been generally beneficial to the Company. We are very much indebted to all of these gentlemen and to the other members of the staff in Buenos Ayres for the care and attention they have given to the Company's business, to which the efficient service to our subscribers is due. One of our Consulting Directors, Mr. Krabbe, is here, and will be happy to answer any questions. Before concluding, I desire to allude to the paragraph in he Directors' report, in which they express their regret at losing Mr. Irwin from the Board, in which expression of regret I feel the shareholders will cordially join. I beg to move—

"*That the report and accounts submitted to the meeting be, and they are hereby received and adopted by the Company.*"

I will now call upon the Manager Director, Mr. Jones, to second the resolution.

Mr. FRANK W. JONES briefly expressed his pleasure at seconding the motion.

The CHAIRMAN: We shall be very pleased to answer any questions or give any further information in our power. After a pause he said: If no questions are put I will ask Mr. Krabbe, who has just returned from the Plate, and who we are very glad to see among us, to say a few words to the shareholders. I am sure that that will meet with your views.

Mr. KRABBE: I am, of course, more accustomed to take a local view of the work of the Company as regards Buenos Ayres than the ultimate result in England. We do our best to send home as much money as possible, and therefore the figures I more generally carry in my head are those absolutely belonging to the Plate. I am very pleased to come before you to-day instead of when the premium was at 350. Comparing in dollars our profit for the year with that of last year, it is $290.000 against $202,000, or, as our Chairman said, nearly 50 per cent. increase. This, of course, arises from two causes, from the subscribers on the one hand and the expenses on the other. There is a third cause which militates on the sterling result, namely, the premium, which is absolutely beyond our control. Our subscribers, I think, show a satisfactory and promising condition. They have increased considerably during the last 12 months, and, without wishing to prophesy, I think we can look forward to their being over 4,000 in Buenos Ayres alone within a short period. Of course, our object is to increase them as much as possible, and there are two causes which tend to an increase. One is naturally beyond our control, and that is the general condition of business out there, but certainly business has improved, apart from all political or gold questions, in the Plate in the last two years, and the condition of the country generally promises to allow a still further improvement. The other point in connection with the subscribers is, naturally, the service; and without wishing to take any praise to ourselves out there I can certainly say that we compare with regard to service very creditable with any other city, and certainly alongside of service that I have experienced lately. We, as a rule, give a prompt and efficient service, giving communication very much more rapidly than they do on this side of the water. Until there is an equilibrium between gold and paper prices out there—that is to say, the value of a sovereign and the value of a man's labour—it would be very difficult for us to economise in dollars any further. To put it more practically, I may say that there are men and women in our employ now who get, say, $40 a month. When gold was low we were paying them $30—that is to say, their wages have only increased 33 per cent., while the premium, as you know, has gone up to 250 points, and more than that. If the premium goes down, if gold becomes cheaper in Buenos Ayres, the wages in paper will not increase, but if the premium rises, it is only natural that wages will rise too. I am very much obliged to the Chairman for the kind way he spoke of us just now. I will only say that I think Mr. Fels, Mr. Chappell, and Mr. Parker, who has been manager at Buenos Ayres for many years, as well as myself, have your interests thoroughly at heart.

The CHAIRMAN then put the resolution to the meeting in the usual way, and it was carried unanimously. He afterwards proposed the re-election of Mr. Frank W. Jones as a Director of the Company. Mr. Jones he added, was the Managing Director, and was constantly with them.

Mr. C. L. W. FITZGERALD seconded the resolution, which was unanimously adopted.

On the motion of the CHAIRMAN, seconded by Mr. J. C. J. DRUCKER, Mr. Frederick Green was also re-elected to his seat at the Board.

Mr. FITZGERALD then proposed, and Mr. J. D. BONNER seconded, the re-election of the auditors, Messrs. Cooper Bros. and Co., at a fee of 25 guineas, and the motion was carried unanimously.

The CHAIRMAN: That concludes the business of the meeting. I think I shall be only expressing the wish of the meeting if I thank Mr. Krabbe for his information, and for the encouraging address he made to us in regard to the affairs of this Company and the affairs of the River Plate, in which we are also deeply interested. We all know that he and all the other members of the staff have had, and that they will continue to have, the interests of the Company at heart.

Mr. DRUCKER afterwards proposed a cordial vote of thanks to the Chairman and Directors for their able administration of the Company's affairs in the very unfavourable times which had been experienced.

Mr. FITZGERALD seconded the motion, which was carried unanimously.

The CHAIRMAN: On behalf of the Directors and myself I thank you very much. We are doing our very best for you. As regards anything in which we have control I believe there is very little fault to be found. We do our best according to our judgment. There are certain matters in which we have no control, and that fact causes us great anxiety, but it is impossible to go through our figures calmly without seeing what progress we have made. The gold question overhangs everything, but if that matter is placed on a satisfactory basis in the future and there is a stable Government, I have no doubt about the future of this Company.

The proceedings then terminated.

Electric Construction Corporation (Limited).

A meeting of the holders of the First Mortgage Debentures of the above-named Company was held on Wednesday, at Worcester House, Walbrook, E.C., Mr. R. E. Beachcroft presiding.

The SECRETARY (Mr. James Gray) having read the notice convening the meeting,

The CHAIRMAN moved the following resolutions:—

"*This meeting hereby sanctions the scheme for the reconstruction of the Electric Construction Corporation (Limited), set forth in the draft Resolutions produced to the meeting, so far as the same affects the holders of the First Mortgage Debentures of the Corporation.*"

"*This meeting approves the forms of the First Mortgage Debentures of the new Company and the Trust Deed to secure the same, which have also been produced to the meeting, and sanctions the exchange of the First Mortgage Debentures of the Corporation for First Mortgage Debentures of the new Company.*"

"*This meeting, pending the exchange of the First Mortgage Debentures of the Corporation for First Mortgage Debentures of the new Company, hereby suspends the right of the holders of the First Mortgage Debentures to take or prosecute against the Corporation any legal proceedings relating to the Debentures.*"

Sir HENRY MANCE, C.I.E., seconded the resolutions, which were carried with one dissentient.

A meeting of the holders of the Second Mortgage Debentures was held on the same day, Mr. E. Garcke (the Managing Director of the Corporation) in the chair.

The CHAIRMAN, in moving a series of resolutions similar to the foregoing, but applicable to the Second Mortgage Debentures, said that the holders had, no doubt, read the circular which accompanied the letter which the Directors had issued to the shareholders of the Corporation, and which set out fully the scheme of re-construction and the position of the debenture-holders. As regarded the First Mortgage Debentures, no change was proposed. With respect to the Income Bonds, it was suggested that they should accept £2 fully-paid Ordinary shares of the new Company of the value of £2 each in exchange for each £10 Income Bond. He thought, on the whole, that they would recognise that there were many advantages in effecting this exchange. The holders would rank with the Ordinary shareholders for dividend, instead of as at present waiting until the debentures to which the Income Bonds were attached had been redeemed. He might say that the Electric and General Investment Company, who were the trustees for this issue, approved the scheme so far as it affected the Second Mortgage Debenture holders, and recommend its adoption. He might also say that a meeting of the holders of the First Mortgage Debentures was held that morning, at which similar resolutions were all but unanimously agreed to, there having been only one dissentient. In regard to the Income Bonds, it would be necessary that they would be asked to sign a declaration of adhesion to the scheme. In regard to the Second Mortgage Bonds, that would have to be decided at once. In answer to Mr. Barclay he added that the trustees who represented them now would also do so in the new company and their security relatively to the first debenture holders, and to the shareholders would remain precisely the same as it was before, and the bonds would be redeemed by drawings half-yearly as at present. The first of these drawings had already taken place, £2,000 having been paid off, so that the total issue was £98,000 instead of £100,000. In answer to a shareholder, he said that the bonds issued last December amounted to £50,000. It would be remembered that the Board then wisely allotted the whole of the issue to the shareholders rateably, and only such bonds as were not taken up by the shareholders were issued to outsiders, and in this way £50,000 was subscribed. The balance of £50,000 remained in the hands of the Company, and had since been issued. They were not asking the shareholders to make any sacrifice. The capital was now being reduced from £10 to £4 shares, and the Income Bonds were reduced in the same proportion. Consequently, they were not making any sacrifice, but on the contrary, they were being benefited. This reconstruction scheme would mean an improved credit for the Company, and enable them to do

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better business than they were now able to do, and their security would be enhanced in value in public estimation.

Mr. BLANDY seconded the resolutions, which were carried unanimously.

An extraordinary general meeting of the Company was subsequently held at the Cannon-street Hotel, the Chairman (Sir Daniel Cooper, Bart., G.C.M.G.) presiding.

The notice convening the meeting having been read,

The CHAIRMAN said: Gentlemen, I explained to you on the occasion of the last general meeting that the Board was in course of being reconstituted. It was suggested by some of the shareholders that a Committee of Investigation should be appointed, and I promised you that the Directors themselves would investigate the whole of the affairs of the Company. Well, the Board has been reconstituted, as we have mentioned in the report which is in your hands. During the past year seven Directors have retired from the Board, and the three new Directors, Mr. Plunket, Mr. Barclay, and Mr. Garcke have been appointed. You will see, therefore, that we are now practically a new Board, and I can assure you that if you had seen how difficult it was for some of us to get control of the business under the old *régime* you would be able to appreciate the full force of what this reconstitution of the Board means. Some of us have been Directors of the Corporation since the commencement, but, as you are aware, the Board was at one time a very large one, consisting of about twelve members, and it was divided into Committees, so that those of us who were not on the Committees were frequently kept in the dark as to what was being done until the steps taken had become irrevocable. I cannot tell you how very grateful I feel for the changes that have been made. These changes have relieved me from a very unenviable position, and I feel much indebted to the members of the present Board for the way in which they have supported me. It has been a very difficult time for all of us, and if we had not stood well together the consequences to the Corporation might have been serious. My colleagues have worked very hard. I had occasion to mention at the last general meeting how my friend Mr. Courtenay had, during the difficult period of transition taken up the reins of management and had prepared the way for the Corporation making the important changes I have referred to. Since then he has been assisted by the new Directors, and they have attended at the office from day to day, and have spent several hours there each day, examining into the affairs of the Corporation, and conferring with the Managing Director as to the reforms which have had to be carried out. One of the first steps we had to take after the last general meeting was to appoint a Managing Director, and the Board consider that they have been fortunate in securing the services of Mr. Garcke, who has had a large and wide experience in the electrical business. It then became necessary to appoint a new secretary, a new accountant, and to make several other changes in the staff, and I am glad to be able to tell you that these changes have already produced very good results. One of the first things that had to be done was to cut down the very heavy standing charges, and the Managing Director, who will address you, will tell you what has been done in the direction of effecting economies. Then the financial position presented many difficulties, and it was only by the Directors coming forward and assisting the Corporation, and undertaking responsibilities for the Corporation, that we were able to meet our various engagements. I shall not regret what I have myself done in this respect if you enable me to feel that we have your support and appreciation. The result of our investigation is that a thorough reorganisation of the business and a reconstruction of the Company is absolutely necessary. It is needless for me, as one of the largest shareholders in the Corporation, to say that I regret the necessity for doing this. I am one of the largest sufferers, and therefore I am able to sympathise with you; and the view that we hope you, as men of business, will take is that it is our bounden duty to remain at our posts and to save what remains, and endeavour to recover what has been lost. The Board are convinced that the best way to carry out the reorganisation is by means of the scheme of reconstruction now before you, and by the formation of a new Company. At present the credit of the Company is prejudiced by the shares being of a large discount, and this makes it very difficult for our managers to get contracts and to carry on the business economically. The position of the Company is by no means what the price of the shares indicate, and I am expressing the views of my colleagues, as well as of myself, when I state that it is our belief that, with the careful management and energy with which we intend to push the business, there is a prosperous future before the new Company. The important contracts which have been entrusted to us, and which we have carried out successfully, by the aid of our Works Director (Mr. Parker) has laid the foundation of profitable work in future. I think it right to tell you that, acting under the advice of the solicitors, I have, as one of the largest shareholders and creditors, filed a petition for winding-up, in order to prevent what are generally known as wrecking petitions. When that petition comes on for hearing I propose to ask the Court to make an order to continue the voluntary winding-up under the supervision of the Court. I now propose the first special resolution, of which you have had notice:—

"*That it is desirable that the Corporation be reconstructed, and that with a view to such reconstruction the Corporation be wound up voluntarily.*"

I will not trouble you with the other resolutions at this stage. I take it we can discuss the position generally upon the first resolution, and if the principle embodied in that resolution is adopted by you, the rest of the resolutions will be put to the vote, and, I hope, carried as a matter of form. I call upon Mr. Garcke, our new Managing Director, to second the resolution.

Mr. E. GARCKE, in seconding the resolution, delivered a long address, setting forth the circumstances under which the new Board entered on their work a few months ago. He said that while the Board were bound to recognise that there had been mismanagement in the past they were satisfied that with strict economy and prudent management in the future there was no reason whatever why they should not retrieve the errors of the past and occupy a leading position, and in many respects the leading position in the electrical industry. Many of their investments were of such a character that if properly developed and taken care of promised not only to become valuable and realisable in cash, but would, he hoped, have the effect of largely increasing the business of the Corporation. He then elaborately explained the scheme of reconstruction, the terms of which were fully set out in *The Electrician* last week.

The Right Hon. D. PLUNKET, Q.C., M.P., also expressed his confidence in the ultimate success of the Company if the scheme of re-construction were carried into effect. The Directors had satisfied themselves that there was a *bonâ fide* valuable property to be worked which had come to grief through mismanagement in the past; but with the re-constituted board, hard work and rigid economy, and straightforward dealing, they would succeed in putting the company on its feet again.

Mr. BEACHCROFT also spoke in support of the scheme, into the details of which he had gone most carefully, without being able to find a single objection to it.

Mr. HANCOCK animadverted on the past management of the Company, after which the resolution was carried unanimously.

All the other formal resolutions giving effect to the reconstruction were afterwards agreed to *nem. con.*

Mr. JAMES W. BARCLAY proposed a vote of thanks to the Chairman, not only for his conduct in the chair, but for the invaluable assistance which he had given to the Company in the difficulties in which it had been placed, not only by his able counsel, but by the money he had put into the concern. He was sure that if they had not been backed up by Sir Daniel the results would have been disastrous.

The Right Hon. D. PLUNKET seconded the motion, which was cordially carried.

The CHAIRMAN having expressed his acknowledgement of the vote, the proceedings ended.

Eastern Telegraph Company (Limited).

The following is the report of the Directors of this Company for the half-year ended March 31st last, to be presented to the forty-second half-yearly Ordinary General Meeting, to be held at Winchester House, E.C., on Thursday, the 13th inst., at one o'clock:—

The revenue for the period amounted to £372,852. 10s., from which are deducted £102,499. 7s. for the ordinary expenses, and £32,532. 17s. 11d. for expenditure relating to repairs and renewals of cables, &c., during the half-year. After providing £5.263. 18s. 8d. for income-tax, there remains a balance of £234,556. 6s. 5d., to which is added £62,942. 4s. 4d., brought from the preceding half-year, making a total available balance of £297,498. 10s. 9d. From this balance there have been paid:—

Interest on debentures and debenture stock	£27,891	0	3
Dividend on Preference shares	20,474	1	8
An interim dividend of 2s. 6d. per share on the Ordinary shares	50,000	0	0
	£98.365	1	11

Leaving a balance of £199,133. 8s. 10d., from which £88,000 has been carried to the general reserve fund.

The Directors now recommend the declaration of a final dividend for the year ended March 31, 1893, of 2s. 6d. per share and a bonus of 3s. per share, amounting together to £110,000, both payable on the 13th inst., free of income tax, and making, with the three previous payments on account, a total distribution of 13s. per share, or 6½ per cent. for the year, on the Ordinary shares. The balance of £1,133. 8s. 10d., shown at the foot of the revenue account, is proposed to be carried forward to the next half-year.

The revenue includes £20,991. 12s. dividends and bonus for the half-year upon the Company's investments in the Eastern and South African, the Black Sea, the Direct Spanish, and the African Direct Telegraph Companies.

Since the last general meeting the Eastern and South African Telegraph Company, under an arrangement with this Company, has entered into an agreement with Her Majesty's Government to connect the Islands of Seychelles and Mauritius with Zanzibar and this Company's general system of cables, in consideration of subsidies amounting to £28,000 per annum for a period of 20 years. To carry out this work the Directors of this Company issued, for account of the South African Telegraph Company, £200,000 Four per Cent. Registered Mortgage Debentures, part of a total authorised issue of £300,000 like Debentures secured upon these subsidies. The subscriptions were largely in excess of the amount offered.

Negotiations have for some time been in progress with the Portuguese Government for connecting the Islands of the Azores with Lisbon and this Company's general system, resulting in an agreement with that Government for the carrying out of this work. A Company is being formed to lay this cable and work it under the conditions of the contract with the Government. It is expected the cable will be laid in August next.

The Directors regret to report the death on May 7th last of their valued and esteemed colleague, Sir James Anderson, Managing Director of the Company since its formation. The vacancy has been filled up by the appointment of Mr. J. Denison Pender, who has been a member of the Board for many years. Mr. C. W. Stronge, C.B., for several years an Official Director, appointed by H.M. Treasury, has, on retiring from that office, been elected an ordinary Director of the Company.

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India-Rubber, Gutta Percha, and Telegraph Works Company (Limited).

The half-yearly general meeting of this Company was held at the Cannon-street Hotel on Wednesday (Mr. S. William Silver in the chair), "for the purpose of obtaining the sanction of the shareholders to the payment of an interim dividend of 5 per cent., or 10s. per share, free of income-tax."

The SECRETARY (Mr. William J. Tyler) having read the notice calling the meeting.

The CHAIRMAN said: That is really the object of our meeting to-day, and we are very glad to see you. You may remember, perhaps, on the last occasion that I referred to a cable that we had just manufactured, between 2,000 and 3,000 miles long, which we were then about to lay in the Pacific. That work has been completed and paid for, and I believe I am justified in saying that it was one of the best cables we have made. With respect to the trade generally, I am very glad to say that the returns are equal to those of previous years—indeed, somewhat in excess. I do not know that I can add to these remarks, but I will ask my friend, the Managing Director, to give you afterwards a report of the French works which he has just paid a personal visit to. I will now conclude by moving that a dividend of 5 per cent., or 10s. per share, free of income-tax, payable on the 6th inst., be now declared.

Mr. ABRAHAM SCOTT: I beg to second the resolution.

The motion was carried unanimously.

The MANAGING DIRECTOR (Mr. Matthew Gray): As the Chairman has just said, I have been within the last few weeks visiting our French works, and I am glad to inform you that everything is going on there satisfactorily. We have very nice little works there, and they are doing very good work, and, I believe, they are doing it on a proper basis, which will give a moderate return for our exertions. I do not think the shareholders need be at all anxious about the French works. I think they are in a very good condition, and they are likely to be satisfactorily managed. I do not know that I have anything else to say as far as the French works are concerned. I regret to tell you that one of our agents, our agent for Ireland, who had been with us for 19 years, and who was a very worthy man, died about three weeks ago of heart disease. I went over to Ireland 0 days ago for the purpose of making arrangements for carrying on our usiness there, and I have just returned, having made, I think, arrangements which will prove satisfactory. Although I express my very sincere egret at the death of our old and worthy agent, still I think it will not turn out so injurious to us as one might have expected, as I think the arrangements now made are such as will enable us to carry on our Irish business in as satisfactory a manner as hitherto. The works at Silvertown are in first-rate condition, and everything is going on in the usual manner, and, I think, satisfactorily. We could do some more cable work, I believe, if we had it to do, but, as you all know, submarine cable work comes in fits and starts. We do the best we can when we get orders, and we must "grin and bear it" when we do not get them.

The CHAIRMAN: That concludes our business, gentlemen, and I thank you for your attendance.

Mr. MARTINDALE said that before the meeting separated he desired to have the privilege of proposing a vote of thanks to the Chairman and Directors. He regarded their dividends as very satisfactory and considered that the thanks of the shareholders were eminently due to those who managed the affairs of the Company in such an efficient manner.

Mr. TREBLE seconded the motion, which was unanimously agreed to.

The CHAIRMAN: We thank you, gentlemen, for this fresh proof of your confidence.

The proceedings then terminated.

NEW COMPANIES, STATUTORY RETURNS, &c.

BINDLEYS (LIMITED).—This Company, which was registered on June 2, 1893, with a capital of £6,000, in £10 shares, for the acquisition of an ironmonger's business at Burton-on-Trent, Staffs., includes among its objects the manufacture and sale of electric, magnetic, telegraphic, telephonic and other apparatus and appliances.

LAMINA ACCUMULATOR (ELIESON'S BRITISH PATENTS) SYNDICATE (LIMITED).—This Company was registered on June 29th with a capital of £2,000, in £1 shares, to enter into and make binding on the Company an agreement to be made with C. P. Elieson for the acquisition of certain patents granted in the United Kingdom of Great Britain and Ireland for and relating to electric accumulators or storage batteries, to develop and turn to account such patents and inventions, to carry on the business of electric light, heat and motive-power supply company in all or any of its branches and in particular to construct, lay down, establish, fix, and carry out all cables, wires, lines, accumulators, lamps, and works necessary for the carrying on of the business of the Company. The subscribers, each one share each, are:—Earl of Galloway, 17, Upper Grosvenor-street, W.; Moritz Immisch, 119, Torriano-avenue, N.W.; A. J. Morison, 10, Mincheap, E.C.; M. Frederison, 8, Regent-street, W.; F. D. Schiattino, 8, Regent-street, W.; Lewis Goldspink, 5, Thornhill-crescent, N.; Alfred Phili, Albion House, Stainsby-road, E. The number of Directors is not to be less than three, nor more than five. The first are:—The Right Hon. the Earl of Galloway (Chairman), Alex. J. Morison, Moritz Immisch, Francisco A. Pellas, and C. P. Elieson.

T. L. HEMMING AND CO. (LIMITED).—The annual return of this Company, recently filed, shows that 421 shares of the nominal capital of £5,000, in £10 shares, have been taken up, of which 130 were issued as fully paid to Thomas L. Hemming, the vendor. Upon 271 shares the full amount has been called up on 10 shares £5 per share, and upon the remaining 10 shares £1 per share, resulting in the payment of £2,770.

WYNDHAM ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to March 3, 1893, and filed in April following, shows that out of a nominal capital of £1,500, in £1 shares, 885 have been taken up. Of these 250 were issued as fully paid, while a call of 15s. per share has been made on the remaining 635, resulting in the payment of £199. 15s., and leaving £276. 10s. in arrears.

CITY NOTES, &c.

CHATHAM, ROCHESTER, AND DISTRICT ELECTRIC LIGHTING COMPANY (LIMITED).—At the adjourned meeting of the shareholders last week it was announced that as a result of the conference between the sub-Committee and the Chairman (Mr. Jasper), the latter gentlemen undertook to sell to any shareholder any of the shares proposed to be allotted to him in consideration of the money he had spent in carrying on the works. A resolution allotting him the shares to the amount of £18,630 was thereupon carried.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended July 2nd were £811, as against £763 for the corresponding period of last year, being an increase of £48. The total receipts for the half-year amount to £22,610, against £20,895 in the corresponding period of 1892, being an increase of £1,715.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of June are £3,200, as compared with £3,420 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY.—The gross receipts for the month of June were £1,730, as compared with £1,966 for the corresponding period of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of June amounted to £62,564, and to £52,173, in the corresponding period of 1892 an increase of £10,391.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of the Eastern Extension, Australasia and China Telegraph Company (Limited) for the month of June, 1893, amounted to £45,443 and to £41,738 in the corresponding period of 1892; increase, £3,705.

ELMORES' FOREIGN AND COLONIAL COPPER DEPOSITING COMPANY (LIMITED).—There was a private meeting of this Company at Winchester House on Friday last.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this Company for June amounted to £24,800, and from January 1st to June 30th to £132,800. In the corresponding months of 1891 and 1892 the amounts were £141,400 and £128,800 respectively.

GULCHER (NEW) ELECTRIC LIGHT AND POWER COMPANY (LIMITED). At the extraordinary general meeting of this Company, held at Winchester House, E.C., on Monday last, the Directors were authorised to create £10,000 in Six per Cent. Second Debentures.

NATIONAL TELEPHONE COMPANY (LIMITED).—The Directors recommend the following dividends, less income-tax, for the last half of the financial year, ended April 30, 1890, viz.:—At the rate of 6 per cent. on the amounts paid-up on the First and Second Preference shares; at the rate of 5 per cent. per annum on the amounts paid-up on the Third Preference shares; at the rate of 5 per cent. on the amounts paid-up on the Ordinary shares, making with the the interim dividend already paid, 5 per cent. for the year, leaving a balance of about £32,000. The transfer books of the Company will be closed from the 5th inst. until the 18th inst., both days inclusive.

ONCKEN'S PATENT STAVELESS BARREL COMPANY (LIMITED).—A private meeting of this Company was held on Monday at the Cannon-street Hotel. An attempt is to be made to obtain further capital.

QUEEN ANNE'S MANSIONS LIGHTING AND HEATING COMPANY (LIMITED).—A meeting of the Debenture holders of this Company will be held at No. 251, Winchester-house, Old Broad-street, on Tuesday next, the 11th inst., at 2 p.m., for the purpose of (1) authorising the trustees under the said deed to assent to and, if considered advisable, concur in the grant of a lease by the Company of the property and premises comprised in the said deed; and (2) sanctioning a modification of the rights of the Debenture holders as regards the date and amount of the sinking fund payments provided for by the said deed.

WEST AFRICAN TELEGRAPH COMPANY (LIMITED).—This Company give notice of the drawing of 110 Five per Cent. Mortgage Debentures of £100 each. These debentures will be paid off at par on September 1st next, at the National Bank of Scotland (Limited), Nicholas-lane, Lombard-street, E.C., and interest will cease after that date.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended June 30, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,369.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED.)—The receipts for the two weeks ended June 30th were £2,292, as compared with £2,196 for the corresponding period of last year.

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YORKSHIRE HOUSE-TO-HOUSE ELECTRICITY COMPANY, LIMITED (LEEDS).—This Company invite subscriptions from the present shareholders of the Company for the remaining 2,634 shares of £5 each, which, if subscribed, will bring the capital of the Company up to £50,000 out of a total authorised capital of £100,000. The money is required (the prospectus states) for an extension of the works at Leeds. The Directors consider that the success already attained justifies them in regarding the Company's shares as a safe and profitable investment, and further state that they already hold more than one-fifth of the subscribed capital and propose to apply for no less than £3,000 of the present issue.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name	Previous Week's Price, June 28.		Price Wednesday, July 5.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 5.	
								£ s. d.		Highest	Lowest
			TELEGRAPHS								
£1,134,640	Stock	12/6	Anglo-American	51	52	51	52	5 5 9	Jan., Apr., July, Oct.	..	..
£2,932,680	Stock	25/0	Do. Preferred	94½	95½	94½	95½	5 15 2	" "	95½	94½
£2,932,680	Stock	5/0	Do. Deferred	10½	11	10	10½	..	" "	10½	..
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)xd	101	104	99	102	3 18 5	January and July	..	..
130,000	£10	3/0	Brazilian Submarine xd	12	12½	11⅞	12½	5 6 1	Mar., June, Oct., Dec.	12⅛	11⅞
£36,400	£100	5%	Do. 5 per Cent. Bonds xd	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906) xd	107	111	106	110	4 10 11	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	138	142	138	142	4 18 7	April and October	..	..
16,000	10	8/0	Cuba Submarine	11½	12½	11½	12½	6 8 0	February and August	12½	11½
6,000	10	10%	Do. Preference 10 per Cent.	18½	19½	18½	19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½	3½	2½	3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅝	12½	11⅝	12½	5 15 8	Jan., Apr., July, Oct.	12	11⅝
400,000	10	2/6	Eastern	15	15½	15½	15½	4 3 10	" "	15⅞	15
70,000	10	6%	Do. 6 per Cent. Preference	16½	17	16½	17	3 10 7	" "	..	..
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112	115	112	115	3 9 7	May and November	113	..
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	108	111	108	111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	15¾	16	15¾	16	4 7 6	Jan., Apr., July, Oct.	15⅛	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114	116	113	116	3 9 0	February & August	..	..
£70 630	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900 xd	104	107	102	105	4 15 3	January and July	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900 xd	103	106	101	104	4 16 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	102	105	102	105	3 16 2	February & August	104⅜	..
£200,000	£25	..	Do. 4% Mauritius Sub. Debs. premium	3½	4	3½	4	..	May and November	..	..
180,227	10	2/3	Globe Telegraph and Trust	9⅜	10	9⅜	10	4 10 0	Jan., Apr., July, Oct.	10	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	15⅝	15⅞	15⅝	15⅞	3 15 7	" "	15⅞	15⅞
160,000	10	5/0	Great Northern xd	19¾	20½	19½	20	4 5 0	Jan., April, and July	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105	108	105	108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	39	42	39	42	5 19 1	May and November	40	39½
37,548	10	4/0	London Platino-Brazilian	4	6	4	6	6 13 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent Debentures	107	110	107	110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs. xd	101	104	99	102	3 18 5	" "	..	..
11,802	8	4/0	Reuter's	5	6	5	6	..	April and October	5	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6 per Cent.	120	125	120	125	4 16 0	" "	..	..
15,609	10	5/0	West African Telegraph	5½	6½	5½	6½	7 13 10	January and July	..	..
£260,980	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	3	4	3	4	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902 xd	103	107	99	103	7 15 4	June and December	..	..
88,321	10	6d.	West India and Panama	1⅛	1⅜	1⅛	1⅜	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½	11½	10½	11	5 9 1	May and November	11⅛	10⅞
4,669	10	6%	Do. 6 per Cent. 2nd Pref	9½	10¼	9½	10½	5 14 3	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917 xd	108	111	105	108	4 12 7	June and December	107½	..
64,242	15	4/6	Western and Brazilian	7¼	7⅜	7¼	7⅜	4 13 11	May and November	7⅜	..
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	6	6½	6	6½	5 15 3	" "	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1½	2	1½	2	..	" "	..	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 10 1	February & August	109	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106	109	106	109	5 10 1	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120	125	120	125	5 12 0	May and November	..	..
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	100	103	100	103	5 16 6	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	2	3	2	3	..	" "	..	..
22,500	14/0	3½d.	Consolidated Telephone Const. & Maintenance	½	½	½	½	..	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	½	½	½	½	7 18 2	Yearly	..	..
458,867	5	2/6	National	5⅛	5⅜	4⅞	5	6 0 0	June and December	5⅜	..
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14⅜	15½	14⅜	15½	3 18 8	" "	14⅝	14
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14½	14⅝	14½	14⅝	4 1 4	" "	14⅝	14⅝
90,950	5	6⅜d.	Do. 5% Non-Cumulative 3rd Pref. (£3 paid)	5⅜	5⅝	5⅜	5⅝	..	..	5⅞	..
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid) xd	113	117	110	115	3 18 3	January and July	113½	..
58,000	5	1/0	United River Plate	2⅞	3	2⅞	3	..	January and July	2⅞	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock xd	90	100	90	100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	11½	12	11½	11⅝	..	..	12⅞	12⅜
20,000	10	..	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12¾	12⅞	12⅝	13	..	..	12¾	12⅜
19,900	£5	..	Electricity Supply Co. for Spain	..		..		..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	..		..		..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	..	..	..
8,322	£5	..	House to House Electric	..		..		..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4⅝	4⅞	4⅝	4⅞	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6⅝	6⅞	6⅝	6⅞	..	..	..	..
111,000	5	..	London Electric Supply	¾	1¼	..		..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6	6½	6	6½	3 1 6	..	6⅜	6⅛
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102	105	102	105	4 15 3	June and December	..	..
6,452	£10	..	Notting Hill Electric	5	6	5	6	..	..	..	..
19,980	£5	9½%	St. James' and Pall Mall	7½	7¾	7½	7¾	..	..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	7¾	8¼	7⅞	8¼	4 4 10	..	8⅛	..
59,900	5	2/0	Westminster Electric Supply (fully paid)	5¼	5½	5¼	5½	3 0 10	..	5⅛	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/6	Brush Electrical Engineering	3	3¼	3	3¼	..	..	..	..
75,000	2	6%	Do. 6 per Cent. Preference	2⅛	2⅜	2⅛	2⅜	5 1 1	..	2⅛	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107	109	107	109	4 2 7	March & September	108¼	107
20,000	5	3/6	Crompton and Co., 7 per Cent. Cumulative Pref.	5¼	5⅜	5¼	5⅜	6 1 9	January and July	5⅜	..
12,139	5	..	Edison and Swan United	..		..		..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	..	..
49,900	10	12/0	Electric Construction	1⅛	2	1⅛	2	..	..	1⅛	1⅛
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜	⅝	¼	½	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1	2	1	2	..	..	..	..
50,000	10	15/0	India Rubber, Gutta Percha & c., Works	22½	23½	23	24	5 4 1	February & August	23½	..
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	2½	3½	2½	3½	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	..		..		..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	5/0	6/0	5/0	6/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	2	2½	1⅞	2⅛	15 19 0	May and November	2⅛	2
37,350	12	24/0	Telegraph Construction and Maintenance	34	36	34	36	5 0 0	March and July	35	34
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103	106	101	104	4 16 2	January and July	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	..		..		..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	½%	City and South London Railway	36	38	36	38	1 12 10	May and November	..	..
37,500	£10	£10	Liverpool Overhead Railway	4⅛	4⅜	4⅛	4⅜	..	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 791.—Vol. XXXI. FRIDAY, JULY 14, 1893. PRICE FOURPENCE. *Annual Subscription (U.K.), 19/6*

NOTES.

The most noteworthy feature of the first number of the *Physical Review*, which lies before us, apart from the printing and paper, which being American, are of course good, is the space devoted to reviews and the manner in which that space is used. Hitherto, the American scientific reviewer has inculcated the monotonous text that all transatlantic geese are swans, and it is, therefore, refreshing to at last see judicious *critiques* by competent critics. Amongst the contributors to the inaugural number are Profs. Nichols and Sheldon and Messrs. Bedell and Crehore, the two last giving a neat geometrical proof of the three-ammeter methods of measuring power.

We publish this week an important article by Mr. Oliver Heaviside on the analogy between gravitational and electromagnetic action. Mr. Heaviside has based his analogy on the supposition that gravitational energy may be located in its medium of propagation in the same way that electromagnetic energy is located in the ether; and that the former, like the latter, propagation is an elastic displacement in a medium possessing a certain amount of inertia. With this assumption it is necessary, among other things, to reconcile the apparently infinite rate of propagation of gravitational force; and this has been done by the author in a very ingenious manner, namely, by the assumption of the extreme smallness of the magnitude of the constant μ, and the consequent negligibleness of the corresponding value of the term T. In order that c should be really infinite it would be necessary to make the constant μ indefinitely small; and this would introduce inconceivable consequences when we should attempt to evolve any physical conception of the process of gravitational action. But it is by no means necessary to assume that the value of c is infinite. If Laplace, in his calculations on solar gravitation, was unable to detect in the motions of the earth and other planets any variation which might indicate the existence of a finite "aberration constant" of gravitation, it by no means followed that such a constant of aberration was non-existent; for it might exist, and yet be too small to be measured either directly (as Laplace proposed) or indirectly by a series of astronomical observations extending over many hundreds of years. Thus, the absence of any detectable constant of aberration is no obstacle in the way of Mr. Heaviside's analogy. On the other hand, however, the qualities required in the ether which might be assumed to permit of such a minute aberration are more subtle than those of the comparatively gross ether with which electricians are supposed to be acquainted; and it is difficult to reconcile the simultaneous existence of both, unless, indeed, the grosser of the two be discontinuous.

Speaking of aberration in relation to gravity and to light, we may remark that the latter phenomenon is one of the most insurmountable obstacles to a complete ether theory. The slant which is given to the apparent direction of a ray of sunlight or starlight is due to the combined motion of the earth through space and the velocity of the light wave. This phenomenon seems to imply that the motion of the earth and of other matter through space does not drag the ether with it; whereas, some experiments by Fizeau and others on the passage of a light ray through a rotating glass cylinder seem to indicate the contrary. If any such aberration exists gravitationally, as it must if the velocity of gravitation is not infinite, the apparent centre of attraction of the sun must execute an elliptic path round its real centre, the amplitude of which will be in proportion to the slowness of the propagation of gravitating force. This eccentricity or wobbling of the centre of attraction would, of course, produce a definite and continual alteration of the earth's orbit and of the orbits of other planets. The consequences of as large an aberration as that of light would be appalling; but the consequences of a very minute aberration might, like that of the tidal evolution which has been discovered by Prof. George Darwin, be only measurable after millions of years.

The approximate method for measuring the strength of a magnetic field, which Mr. Russell suggests in this issue, may prove convenient in some cases. The apparatus needed is certainly of the simplest kind; but an ammeter is a necessary adjunct, and, although the instrument is now common enough in laboratories, it should be remembered that when an ammeter is available the simplest method of getting a fairly accurate value of H is to make use of an ordinary tangent galvanometer. This instrument, which is found in every laboratory, is usually employed to measure the strength of a current, the value of H being assumed. The process can, however, be reversed when a current of known value can be passed through the coils, since the instrument can then be used to determine the strength of the controlling field. The objection urged by Mr. Russell against the magnetometer method, that the magnetic needle must be small to secure good results, applies

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with equal force to his own method, which has the further disadvantage that the wire conveying the current must be long compared with the distance of the magnetic needle. This fault is not present in the tangent galvanometer method. Mr. RUSSELL's plan may, however, be utilised in another way, and we suggest the following process for forming a rough estimate of the number of amperes flowing in a vertical wire. If a small compass needle be placed east or west of the wire at such a distance that the magnetic force due to the current exactly neutralises that of the earth, this distance, reckoned in centimetres, will be practically equal to the current in amperes.

UNTIL medical electricians discard the cacophonous and archaic terminology in which the majority of them at present indulge we are afraid medical electricity will find it difficult to succeed in freeing itself from the suspicion of quackery under which it at present labours. In a recent communication to the Académie des Sciences, for instance, M. D'ARSONVAL commences by telling us that in electrotherapeutics the three principal methods of treatment are *franklinisation*, *voltaisation*, and *faradisation*, to which he himself has added two new forms of torture yclept *sinusoidal voltaisation* and *high-frequency electrification*, and now proposes a third horror, to be called *auto-conduction*.

FOR the purposes of carrying out auto-conduction M. D'ARSONVAL employs a cylindrical framework of wood or glass around which he winds several turns of electric light cable. The patient is placed inside this cage, and an oscillatory discharge from a condenser is sent through the cable. The condenser, consisting of from two to twelve Leyden jars, 50cm. high by 20cm. in diameter, arranged in two groups "in cascade," is charged by a 15,000-volt transformer connected to a Siemens 60 ∿ alternator capable of giving 12 amperes and 350 volts.

M. D'ARSONVAL's method requires the reproduction of magnetic fields of identical intensity, and his way of doing this is ingenious. Inside a subsidiary coil connected in series with the main solenoid he places a mercury thermometer; the Foucault currents generated in it by the varying field raise the temperature, and the temperature, provided the frequency is constant, gives a measure of the field strength. With four Leyden jars in circuit, the thermometer runs up to more than 150°C. in a few seconds.

SATISFACTORY meters and satisfied consumers are, it would seem, as rare in Germany as elsewhere. In Cologne, indeed, the city authorities have found it necessary to reassure the discontented public mind by a pamphlet, pointing out that the complaints which have been rife among the consumers of municipal electricity that their bills are too high are due to the elementary fact that 80 watt 25 candle lamps have been fixed in lieu of the more humble and usual 16 c.p. lamp. Henceforth the municipality proposes itself to sell lamps for 8d., giving 16-19 Hefner candles and taking from 52 to 56 watts to start with, these figures being respectively 10-12 candles and 40-45 watts at the end of 800 hours. It is not surprising therefore, to learn that in Cologne, at any rate, the demand for current continues to increase, notwithstanding the growing favour of the Welsbach burner, that powerful competitor of the German glow lamp. The Cologne municipal station has at present the equivalent of 32,000 8 c.p. lamps connected to its mains.

SHOULD the large sums which the National Telephone Company are by all accounts lavishing on their London system fail to render telephonic communication in the metropolis all that it ought to be, it is satisfactory to know that a sure remedy lies ready to hand—we must all learn French. According to the Association Professionnelle des Sténographes Français, the result of two years' experience on the London-Paris telephone line is to demonstrate the telephonic inferiority of the English language, and the superiority of French. The consequence of our evil habit of accentuating one syllable, usually the first, of each word, is said to be that the accentuated syllable as often as not arrives all alone at the far end of the line. On the other hand, the French and democratic custom of placing all the syllables of a word on an absolute equality gives them all an equally good chance of getting through. The facts seem to favour this view of the matter, and the theory, of course, is—sound.

IT is stated that in accordance with a curious custom which obtains in France, 10frs. was paid to each shareholder attending a recent meeting of the Société Générale des Téléphones. New telephone companies do not seem to thrive on English soil, but should such a one ever be started again, the prospect of a fee for attending the meetings might, perhaps, induce its shareholders to at least make a vigorous effort to maintain the concern in a position of freedom and independence.

AN inventor is one of those distinguished individuals who are born, not made. Some of us are so lacking in inventive instinct that even under extremest pressure we could not invent so much as a plausible excuse. Some, on the other hand, work out inventions in their dreams. No one, so far as we know, has as yet been bold enough to write a book on "How to Become a Poet," yet variations on the title "How to Become an Inventor" are as plentiful as variations on "Home, Sweet Home." To take to poetry as a profession would be deemed ridiculous; yet to take to inventing as a sole means of livelihood seems to some a most natural proceeding. What this leads to more often than not is exemplified by the fate of the late M. ARCHEREAU, whose death we recorded in our issue of February 24th last, and upon whose grave there was laid, a few days ago, the conventional "très belle couronne," subscribed for by the "Syndicat des Inventeurs de France" and others. ARCHEREAU died in poverty, yet during the siege of Paris he rendered a national service, which was scarcely adequately rewarded by a pension of 10d. per diem. The hospitals were sadly in want of fuel, and remembering that ARCHEREAU was the inventor of *briquettes* they

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applied to him for assistance. Within a week he was turning out for them some 80 tons of coke *briquettes* a day. The moral would seem to be that all who prefer a comfortable competence on this side of the Styx to a "very beautiful crown" on the other should eschew works pretending to tell them "How to Become an Inventor," and strenuously cultivate the business faculty.

Interurban Telephony.—The telephone trunk line between Berlin and Königsberg, a distance of about 500 miles, has now been completed, and a section is in operation.

Dielectric Constants of Biaxial Crystals.—In a recent number of the *Comptes Rendus* there is an interesting account of the researches of M. Borel on this subject. The results of experiments on a large number of crystals are published.

Cable Interruptions.—

	Interrupted.
Paramaribo—Cayenne	April 15th.
St. Thome—Loanda	May 30th.

Lightning Conductors.—In spite of the fact that Rounton Grange, in Northumberland, was provided with three separate lightning conductors, the building was struck by lightning in the recent severe storm. Little damage was done except in the shattering of a portion of the masonry.

Austin (Texas).—The City of Austin (Texas) has in course of construction some large reservoirs for storing potable water. A power house is to be erected close to the main dam to contain eight 500 H.P. horizontal turbines driving dynamos intended to supply light and power to the city three miles off.

Kensington Vestry and Electric Lighting.—At a meeting of the Kensington Vestry, last week, Major-General C. E. Webber was appointed consulting electrical engineer to jointly report with the Vestry's lighting engineer as to the advisability of the Vestry applying for a Provisional Order for electric lighting purposes.

Owen's College, Manchester.—Bishop Berkeley Research Fellowships have been awarded by the Council as follows:—H. B. Pollard, M.A. (Oxon), in Zoology; Albert Griffiths, M.Sc. (Vict.), in Physics; J. A. Harker, D.Sc. (Tübingen), in Physics; Bevan Lean, B.A., B.Sc. (London), in Chemistry; and a Fellowship has been renewed to Stanley Dunkerley, M.Sc. (Vict.) in Engineering.

Telegraphy in Siam.—The interruptions in the Siamese telegraph service, says the *Indian Engineer*, have been so frequent and continuous of late that the principal firms of Bangkok met to discuss what steps should be taken to secure some improvement in the service. It was decided to petition the Foreign Minister with a view of remedying the grievance. The principal German traders also held a meeting in the German Club with the same object.

The Central London Railway.—In the City, at junctions of the various streets near the Mansion House, portions of the roadway close to the footpath have been boarded over and railed-in. These points mark the sizes and positions of the proposed approaches to the underground station. By arranging to have several entrances to this principal station, it will be provided that neither the passengers nor the public will be under the necessity of crossing the crowded roadways.

Colliery Accident.—A singular accident, arising from a faulty arrangement of electric signal wires in a coalpit, was described by the Manager of the National Colliery, Wattstown, at a recent meeting of colliery officials at Pontypridd. It seems that a fall of roof occurred at the in-take; and a quantity of the *débris* falling upon the signal wires, brought them into contact with each other. The heat generated at the contact ignited the coal dust which fell upon the wires, and an outbreak of fire occurred.

Gas and Electricity.—Some interesting facts and figures on "the present and future competition between gas and electricity" are to be found in a recent number of the *Gas World*. The information relates particularly to the United States. At the present time, out of 928 gas companies in the United States, only 435 have contracts for street lighting, and many of these are in competition with electric lighting. The arc lighting in the United States involves an annual consumption of 145,000,000 carbons.

Arc Lamp Fatality.—On the Piazza Quirinal at Rome two electric light lampmen recently lost their lives. One of the large lamps opposite the Palace suddenly went out. The lampman belonging to the district brought a ladder and ascended, but had scarcely touched the carbon when he fell to the ground from a height of some 16ft. His companion, believing him to be seized with sudden illness, went up in his place, but also immediately fell. Both men had neglected to use the switch short-circuiting the lamp. The men were both dead.

Telephonic Communication in the United States.—The following table shows the mileage of wire in use in the United States for telephonic communication at the commencement of each of the last twelve years:—

	Miles.		Miles.
1892.....	52,205	1888.....	202,617
1883.....	83,105	1889.....	243,764
1884.....	115,265	1890.....	279,941
1885.....	137,223	1891.....	331,642
1886.....	155,791	1892.....	381,554
1887.....	172,928	1893.....	421,027

Telephone Wayleaves.—The Highway Committee of the West Riding County Council have recommended that notice should be given terminating all existing agreements with the National Telephone Company, permitting the Company to erect poles on the main roads of the Riding, with a view to new agreements being entered into, containing, amongst other provisions, a reservation in favour of the County Council to carry not exceeding two private lines of wires for county purposes along all poles belonging to or under the control of the Company within the Riding.

Electrolytic Copper.—An immense electrolytic copper refinery has, says the *Engineering Magazine*, been started at Great Falls, Montana, by a Boston Company. It comprises 288 depositing vats, capable of containing at one time 710 tons of pig copper anodes, and has a capacity of 555 tons of pure electrolytic copper per month. The plant is run by water power, situated at a distance of about half-a-mile from the works. The current is supplied by two 165 kilowatt dynamos. The metal to be refined contains a large percentage of silver, all of which will be saved by the electrolytic process employed.

The Latest Form of Trolly.—According to the *Baltimore Sun* the novel sight of a man taking the place of the trolly-rod on an electric car was recently seen on the Lake Roland Elevated Railway. The trolly on one of the large electric cars was caught in a wire, and the entire trolly apparatus was torn off, falling to the street. The accident happened at a time when the traffic was heavy, and it was necessary to prevent a block. A linesman was equal to the occasion. He procured a piece of insulated wire, and after stripping each end of the insulating material, connected one end through the car roof and standing on the top of the car, held the other end against the wire. A connection being thus made the car was run over the elevated stucture to the car shed without accident or delay to the other cars.

Electric Traction in Naples.—As a rule we are somewhat chary of noticing projected schemes, but a railway concession recently obtained by Signor A. Avena certainly claims attention. It is proposed to bridge the lower part of the town by viaducts carried from hill to hill. The populous and beautiful part of the town which centres in the Via Roma is only connected with the Corso Vittorio Emmanuele, the hill of St. Martino and the Rione del Vomero by steep and narrow streets, many of which are impassable to carriages, and the proposed line is to be carried on two iron viaducts, each bearing one line of rails and a passenger way. The viaducts are to be carried on towers 300ft. or 400ft. high, so as to end at the Rione del Vomero on a level with the top of the hill. Lifts are, of course, to be provided.

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The Inefficiency of the Sun as a Means of Illumination.—Prof. Blake, of the University of Kansas, in a lecture delivered in that town makes the following comparison between the light of the sun and of the electric light at the Chicago Exhibition. By Prof. Langley's experiments on Mount Whitney, the Professor states 1·6 kilowatt of energy per square metre of earth's surface is received from the sun when vertical, of this only 35 per cent. is light. The area of the Exhibition grounds is 1,037 acres, or 4,200,000 square metres. To light this space by the sun we should require 1,466,500,000 watts, or 1,965,000 H.P. In lighting the grounds by electricity, using 5,200 arc and 90,000 incandescent lamps, 14,200 H.P. are expended. So that if we like to overlook the difference in quality and quantity we may plume ourselves upon the fact that the sun expends about 145 times more energy to light the Exhibition grounds than man.

Electric Power for Factories.—At a recent meeting of the New England Cotton Manufacturers' Association a Paper was read describing some recent developments in electric power transmission and distribution. The author stated that multiphase synchronous motors were to be used in transmitting power from Sewall's Falls on the Merrimac River to Concord, N.H., a distance of some four miles. There is a total available power at this place of 5,000 H.P., and it is expected that about 3,500 H.P. will be transmitted and utilised. One of the most valuable applications of the electric motor is to the direct driving of calico-printing machines. At the Dunnell Print Works at Pawtucket a motor has been at work for 18 months driving a seven-roll printing machine. The uniformity of motion and the ease and smoothness with which the speed can be regulated have enabled the cloth to be printed at 50 per cent. greater speed than by the old steam-driven machine; and allowing for stoppages to change rolls, at least one-third greater output per machine is obtained.

Removing Arsenic from Copper.—One of the most deleterious impurities commonly found in commercial copper, and one which it is very difficult to eliminate, is arsenic. A very small percentage of this lowers the electrical and thermal conductivities of the metal, and renders it brittle. An addition to the ordinary Welsh process of refining copper has recently been brought out in America by a Mr. Stone. The modification is introduced immediately before the "poling" of the refined metal in a molten state with green timber. It consists in allowing the copper to oxidise until it is brittle and gives a dull red fracture, and then adding nitrate, carbonate or hydrate of potassium or sodium to the molten metal. The weight of salt or oxide added is equal to ten times the weight of arsenic to be separated out in the form of slag; and the metal is kept in a molten state for about 20 or 30 minutes after its addition. The refined metal is tapped into pigs, care being taken to prevent any admixture of the slag with the metal, and it is subsequently poled in the usual manner.

Thunderstorms.—Violent, widespread, and disastrous have been the recent thunderstorms which have resulted, probably, from the prolonged period of dry and hot weather. One remarkable feature of many of these storms has been the absence of rain, notwithstanding that the clouds have gathered thickly overhead. Another feature was the fall of large hailstones, in certain quarters, during the storms, resulting—as at Harrogate and Richmond, on Saturday last—in wholesale destruction of windows. The danger of using the telephone during thunderstorms has again been emphasised in several towns; and in a few cases fires seem to have resulted from telephone wires being struck. Chimneys appear to be specially attractive to the lightning; for, in a large proportion of the instances where houses have been struck the lightning seems to have descended the chimneys—probably on account of the higher conductivity of the hot air and wrought havoc in the rooms where chimneys terminated. The moral seems to be to avoid fireplaces during thunderstorms. The popular feeling against standing under trees seems to be justified by the great number of people and cattle either killed or severely injured while sheltering from the rain beneath trees. A man was killed at Boothen, near Stoke, while standing under a tree. At Hanley, in Staffordshire, one man was killed and four were injured, the men having taken shelter under the arches of the chimney of the electric light works. Near Scarborough considerable damage was done, a man being killed instantaneously at Ebberston.

Commercial Rivalries at the Chicago Exhibition.—"Much interest," says the *Western Electrician*, "has been manifested among the exhibitors in the Electricity Building over the controversy that has been in progress since the Westinghouse Electric and Manufacturing Company began work for its large electric sign on the inside of the southern wall of the Building." Up to the time that the Westinghouse Company had begun to get its exhibit in order it would appear that the most conspicuous feature in the Electricity Building was the General Electric Company's "Tower of Light." This, however, seems to have been surpassed as an advertising medium by a wall decoration of the Westinghouse Company, which was visible from all parts of the building. The overshadowing of their tower of light caused the representatives of the General Electric Company to immediately enter an emphatic protest against the wall decoration, it being asserted that the rival design was "wholly inartistic, amounting to nothing less than a disfigurement of the building, and totally out of place." To this sweeping impeachment the Westinghouse Company replied that Exhibitions were meant for advertising, and they intended to advertise themselves as much as possible. Mr. Barrett, head of the Electrical Department, supported the Westinghouse Company's contention. The matter was then carried to Mr. Burnham, the Director of Works, who, "after consultation with the Exposition artists," held that the Westinghouse advertisement was not in harmony with the rest of the building, and ordered it to be removed. Mr. Barrett, however, refused to obey, alleging that Mr. Burnham had no jurisdiction in the matter. Meanwhile the General Electric Company had endeavoured to induce other exhibitors to sign a petition praying for the removal of the obnoxious advertisement, but to no effect. The dispute was then carried as high as President Higinbotham, who upheld the Westinghouse Company, and it was finally taken higher still, namely, to the Council of Administration, who decided that the advertisement was to be allowed to remain.

An American Engineering Laboratory.—English professors, engaged in the wearing task of endeavouring to scrape together a few hundred pounds to enable them to equip their engineering laboratories with the irreducible minimum of apparatus, will read with mixed feelings a brief well-illustrated account of the new engineering laboratory at the Pennsylvania University, which appeared in the *Electrical World* of July 1st:—There are two buildings, comprising in all about 23,000 sq. ft. of floor. In the one-story boiler-house are seven boilers of the largest size. The manufacturers have taken special pains to make each a model of its kind, and the design has been to represent all varieties. All have been arranged to be tested by the students, and every appointment, while plain and simple, is of the most substantial and convenient kind. One section of this building is given up to the calorimeters, of which there are examples of all the well-known types. Immediately adjoining the boiler-house is the laboratory building, three and a-half stories high, and of mill construction. On the first floor are the engine-room and a mechanical laboratory. The former contains at present a 100 H.P. Westinghouse compound engine, driving Brush and United States dynamos, and a 100 H.P. Porter-Allen engine, driving Edison and Thomson-Houston dynamos. A 100 H.P. Armington and Sims engine, a 100 H.P. straight line engine, and a 50 H.P. Buckeye engine, together with five more direct and alternating-current dynamos of various types, are to be put in place in the near future. In the mechanical laboratory are a 45 H.P. Porter-Allen engine and a 30 H.P. Corliss engine. There are also several steam pumps and a large cistern and weir. The Porter-Allen engine supplies power for the adjoining wood and iron shops, but the Corliss engine is used for nothing but testing. The engine plant is completed by six other small engines which drive rotary fans. On the second floor are the library and reading rooms and a large mechanical and electrical laboratory. The third floor is given up to a drawing-room, a class-room and office, and an electrical laboratory. The fourth floor contain a blue print-room and a model room.

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A GRAVITATIONAL AND ELECTROMAGNETIC ANALOGY.

BY OLIVER HEAVISIDE.

To form any notion at all of the flux of gravitational energy, we must first localise the energy. In this respect it resembles the legendary hare in the cookery book. Whether the notion will turn out to be a useful one is a matter for subsequent discovery. For this, also, there is a well-known gastronomical analogy.

Now, bearing in mind the successful manner in which Maxwell's localisation of electric and magnetic energy in his ether lends itself to theoretical reasoning, the suggestion is very natural that we should attempt to localise gravitational energy in a similar manner, its density to depend upon the square of the intensity of the force, especially because the law of the inverse squares is involved throughout.

Certain portions of space are supposed to be occupied by matter, and its amount is supposed to be invariable. Furthermore, it is assumed to have personal identity, so that the position and motion of a definite particle of matter are definite, at any rate relative to an assumed fixed space. Matter is recognised by the property of inertia, whereby it tends to persist in the state of motion it possesses; and any change in the motion is ascribed to the action of force, of which the proper measure is, therefore, the rate of change of quantity of motion, or momentum.

Let ρ be the density of matter, and $\mathbf{e}$ the intensity of force, or the force per unit matter, then

$$\mathbf{F} = \mathbf{e}\rho \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

expresses the moving force on ρ, which has its equivalent in increase of the momentum. There are so many forces nowadays of a generalised nature, that perhaps the expression "moving force" may be permitted for distinctness, although it may have been formerly abused and afterwards tabooed.

Now the force $\mathbf{F}$, or the intensity $\mathbf{e}$, may have many origins, but the only one we are concerned with here is the gravitational force. This appears to depend solely upon the distribution of the matter, independently of other circumstances, and its operation is concisely expressed by Newton's law, that there is a mutual attraction between any two particles of matter, which varies as the product of their masses and inversely as the square of their distance. Let $\mathbf{e}$ now be the intensity of gravitational force, and $\mathbf{F}$ the resultant moving force, due to all the matter. Then $\mathbf{e}$ is the space-variation of a potential, say,

$$\mathbf{e} = \nabla \mathrm{P}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and the potential is found from the distribution of matter by

$$\mathrm{P} = \mathrm{pot}\,\frac{\rho}{c} = \Sigma\,\frac{\rho}{4\pi c r},$$

where c is a constant. This implies that the speed of propagation of the gravitative influence is infinitely great.

Now when matter is allowed to fall together from any configuration to a closer one, the work done by the gravitational forcive is expressed by the increase made in the quantity $\Sigma\frac{1}{2}\mathrm{P}\rho$. This is identically the same as the quantity $\Sigma\frac{1}{2}c\mathbf{e}^2$ summed through all space. If, for example, the matter be given initially in a state of infinitely fine division, infinitely widely separated, then the work done by the gravitational forcive in passing to any other configuration is $\Sigma\frac{1}{2}\mathrm{P}\rho$ or $\Sigma\frac{1}{2}c\mathbf{e}^2$, which therefore expresses the "exhaustion of potential energy." We may therefore assume that $\frac{1}{2}c\mathbf{e}^2$ expresses the exhaustion of potential energy per unit volume of the medium. The equivalent of the exhaustion of potential energy is, of course, the gain of kinetic energy, if no other forces have been in action.

We can now express the flux of energy. We may compare the present problem with that of the motion of electrification. If moved about slowly in a dielectric, the electric force is appreciably the static distribution. Nevertheless, the flux of energy depends upon the magnetic force as well. It may, indeed, be represented in another way, without introducing the magnetic force, but then the formula would not be sufficiently comprehensive to suit other cases. Now what is there analogous to magnetic force in the gravitational case? And if it have its analogue, what is there to correspond with electric current? At first glance it might seem that the whole of the magnetic side of electromagnetism was absent in the gravitational analogy. But this is not true.

Thus, if $\mathbf{u}$ is the velocity of ρ, then $\rho\mathbf{u}$ is the density of a current (or flux) of matter. It is analogous to a convective current of electrification. Also, when the matter ρ enters any region through its boundary, there is a simultaneous convergence of gravitational force into that region proportional to ρ. This is expressed by saying that if

$$\mathbf{C} = \rho\mathbf{u} - c\dot{\mathbf{e}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

then $\mathbf{C}$ is a circuital flux. It is the analogue of Maxwell's true current; for although Maxwell did not include the convective term $\rho\mathbf{u}$, yet it would be against his principles to ignore it. Being a circuital flux, it is the curl of a vector, say

$$\mathrm{curl}\,\mathbf{h} = \rho\mathbf{u} - c\dot{\mathbf{e}}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

This defines $\mathbf{h}$ except as regards its divergence, which is arbitrary, and may be made zero. Then $\mathbf{h}$ is the analogue of magnetic force, for it bears the same relation to flux of matter as magnetic force does to convective current. We have

$$\mathbf{h} = \mathrm{curl\ pot}\,\mathbf{C}, \quad . \quad . \quad . \quad . \quad . \quad (6)$$
$$= \mathrm{curl}\,\mathbf{A},$$

if $\mathbf{A} = \mathrm{pot}\,\mathbf{C}$. But, since instantaneous action is here involved, we may equally well take

$$\mathbf{A} = \mathrm{pot}\,\rho\mathbf{u}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

and its curl will be $\mathbf{h}$. Thus, whilst the ordinary potential P is the potential of the matter, the new potential $\mathbf{A}$ is that of its flux.

Now if we multiply (5) by $\mathbf{e}$, we obtain

$$\mathbf{e}\,\mathrm{curl}\,\mathbf{h} = \mathbf{e}\rho\mathbf{u} - \mathbf{e}c\dot{\mathbf{e}}, \quad . \quad . \quad . \quad . \quad . \quad (8)$$

or, which is the same,

$$\mathrm{conv}\,\mathbf{V}\mathbf{e}\mathbf{h} = \mathbf{F}\mathbf{u} - \dot{\mathrm{U}}, \quad . \quad . \quad . \quad . \quad . \quad (9)$$

if $\mathrm{U} = \frac{1}{2}c\mathbf{e}^2$. But $\dot{\mathrm{U}}$ represents the rate of exhaustion of potential energy, so $-\dot{\mathrm{U}}$ represents its rate of increase, whilst $\mathbf{F}\mathbf{u}$ represents the activity of the force on ρ, increasing its kinetic energy. Consequently, the vector $\mathbf{V}\mathbf{e}\mathbf{h}$ expresses the flux of gravitational energy. More strictly, any circuital flux whatever may be added. This $\mathbf{V}\mathbf{e}\mathbf{h}$ is analogous to the electromagnetic $\mathbf{V}\mathbf{E}\mathbf{H}$ found by Poynting and myself. But there is a reversal of direction. Thus, comparing a single moving particle of matter with a similarly-moving electric charge, describe a sphere round each. Let the direction of motion be the axis, the positive pole being at the forward end. Then in the electrical case the magnetic force follows the lines of latitude with positive rotation about the axis, and the flux of energy coincides with the lines of longitude from the negative pole to the positive. But in the gravitational case, although $\mathbf{h}$ still follows the lines of latitude positively, yet since the radial $\mathbf{e}$ is directed to instead of from the centre, the flux of energy is along the lines of longitude from the positive pole to the negative. This reversal arises from all matter being alike and attractive, whereas like electrifications repel one another.

The electromagnetic analogy may be pushed further. It is as incredible now as it was in Newton's time that gravitative influence can be exerted without a medium; and, granting a medium, we may as well consider that it propagates in time, although immensely fast. Suppose, then, instead of instantaneous action, which involves

$$\mathrm{curl}\,\mathbf{e} = 0, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

we assert that the gravitational force $\mathbf{e}$ in ether is propagated at a single finite speed v. This requires that

$$v^2\nabla^2\mathbf{e} = \ddot{\mathbf{e}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

for this is the general characteristic of undissipated propagation at finite speed. Now,

$$\nabla^2 = \nabla\,\mathrm{div} - \mathrm{curl}^2,$$

so in space free from matter we have

$$-v^2\,\mathrm{curl}^2\,\mathbf{e} = \ddot{\mathbf{e}}. \quad . \quad . \quad . \quad . \quad . \quad (12)$$

But we also have, by (5),

$$-\mathrm{curl}\,\mathbf{h} = c\dot{\mathbf{e}}, \quad . \quad . \quad (13)$$

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away from matter. This gives a second value to $\ddot{\mathbf{e}}$, when we differentiate (13) to the time, say

$$\ddot{\mathbf{e}} = -\frac{1}{c}\operatorname{curl}\dot{\mathbf{h}}. \quad . \quad . \quad . \quad . \quad . \quad (14)$$

So, by (12) and (14), and remembering that we have already chosen $\mathbf{h}$ circuital, we derive

$$cv^2 \operatorname{curl}\mathbf{e} = \dot{\mathbf{h}}. \quad . \quad . \quad . \quad . \quad . \quad (15)$$

Or, if μ is a new constant, such that

$$\mu c v^2 = 1, \quad . \quad . \quad . \quad . \quad . \quad (16)$$

then (15) may be written in the form

$$\operatorname{curl}\mathbf{e} = \mu\dot{\mathbf{h}}. \quad . \quad . \quad . \quad . \quad . \quad (17)$$

To sum up, the first circuital law (5), or

$$\operatorname{curl}\mathbf{h} = \rho\mathbf{u} - c\dot{\mathbf{e}}, \quad . \quad . \quad . \quad . \quad (18)$$

leads to a second one, namely (17), if we introduce the hypothesis of propagation at finite speed. This, of course, might be inferred from the electromagnetic case.

In order that the speed v should be not less than any value that may be settled upon as the least possible, we have merely to make μ be of the necessary smallness. The equation of activity becomes, instead of (9),

$$\operatorname{conv} V\mathbf{eh} = \mathbf{Fu} - \dot{\mathrm{U}} - \dot{\mathrm{T}}, \quad . \quad . \quad . \quad (3)$$

if $\mathrm{T} = \frac{1}{2}\mu\mathbf{h}^2$. The negative sign before the time-increase of this quantity points to exhaustion of energy, as before. If so, we should still represent the flux of energy by $V\mathbf{eh}$. But, of course, T is an almost vanishing quantity when μ is small enough, or v big enough. Note that $\mathbf{h}$ is not a negligible quantity, though the product $\mu\mathbf{h}$ is. Thus results will be sensibly as in the common theory of instantaneous action, although expressed in terms of wave-propagation. Results showing signs of wave-propagation would require an inordinately large velocity of matter through the ether. It may be worth while to point out that the lines of gravitational force connected with a particle of matter will no longer converge to it uniformly from all directions when the velocity v is finite, but will show a tendency to lateral concentration, though only to a sensible extent when the velocity of the matter is not an insensible fraction of v.

The gravitational-electromagnetic analogy may be further extended if we allow that the ether which supports and propagates the gravitational influence can have a translational motion of its own, thus carrying about and distorting the lines of force. Making allowance for this convection of $\mathbf{e}$ by the medium, with the concomitant convection of $\mathbf{h}$, requires us to turn the circuital laws (17), (18) to

$$\operatorname{curl}(\mathbf{e} + \mu V\mathbf{qh}) = \mu\dot{\mathbf{h}}, \quad . \quad . \quad . \quad . \quad (19)$$

$$\operatorname{curl}(\mathbf{h} + cV\mathbf{eq}) = \rho\mathbf{u} - c\dot{\mathbf{e}}, \quad . \quad . \quad . \quad (20)$$

where $\mathbf{q}$ is the velocity of the medium itself.

It is needless to go into detail, because the matter may be regarded as a special and simplified case of my investigation of the forces in the electromagnetic field, with changed meanings of the symbols. It is sufficient to point out that the stress in the field now becomes prominent as a working agent. It is of two sorts, one depending upon $\mathbf{e}$ and the other upon $\mathbf{h}$, analogous to the electric and magnetic stresses. The one depending upon $\mathbf{h}$ is, of course, insignificant. The other consists of a pressure parallel to $\mathbf{e}$ combined with a lateral tension all round it, both of magnitude $\frac{1}{2}c\mathbf{e}^2$. This was equivalently suggested by Maxwell. Thus two bodies which appear to attract are pushed together. The case of two large parallel material planes exhibits this in a marked manner, for $\mathbf{e}$ is very small between them, and relatively large on their further sides.

But the above analogy, though interesting in its way, and serving to emphasise the non-necessity of the assumption of instantaneous or direct action of matter upon matter, does not enlighten us in the least about the ultimate nature of gravitational energy. It serves, in fact, to further illustrate the mystery. For it must be confessed that the exhaustion of potential energy from a universal medium is a very unintelligible and mysterious matter. When matter is infinitely widely separated, and the forces are least, the potential energy is at its greatest, and when the potential energy is most exhausted, the forces are most energetic!

Now there is a magnetic problem in which we have a kind of similarity of behaviour, viz., when currents in material circuits are allowed to attract one another. Let, for completeness, the initial state be one of infinitely wide separation of infinitely small filamentary currents in closed circuits. Then, on concentration to any other state, the work done by the attractive forces is represented by $\Sigma\frac{1}{2}\mu\mathbf{H}^2$, where μ is the inductivity and $\mathbf{H}$ the magnetic force. This has its equivalent in the energy of motion of the circuits, or may be imagined to be so converted, or else wasted by friction, if we like. But, over and above this energy, the same amount, $\Sigma\frac{1}{2}\mu\mathbf{H}^2$, represents the energy of the magnetic field, which can be got out of it in work. It was zero at the beginning. Now, as Lord Kelvin showed, this double work is accounted for by extra work in the batteries or other sources required to maintain the currents constant. (I have omitted reference to the waste of energy due to electrical resistance, to avoid complications.) In the gravitational case there is a partial analogy, but the matter is all along assumed to be incapable of variation, and not to require any supply of energy to keep it constant. If we asserted that $\frac{1}{2}c\mathbf{e}^2$ was stored energy, then its double would be the work done per unit volume by letting bodies attract from infinity, without any apparent source. But it is merely the exhaustion of potential energy of unknown amount and distribution.

Potential energy, when regarded merely as expressive of the work that can be done by forces depending upon configuration, does not admit of much argument. It is little more than a mathematical idea, for there is scarcely any physics in it. It explains nothing. But in the consideration of physics in general, it is scarcely possible to avoid the idea that potential energy should be capable of localisation equally as well as kinetic. That the potential energy may be itself ultimately kinetic is a separate question. Perhaps the best definition of the former is contained in these words:—Potential energy is energy that is not known to be kinetic. But, however this be, there is a practical distinction between them which it is found useful to carry out. Now, when energy can be distinctly localised, its flux can also be traced (subject to circuital indeterminateness, however). Also, this flux of energy forms a useful working idea when action at a distance is denied (even though the speed of transmission be infinitely great, or be assumed to be so). Any distinct and practical localisation of energy is therefore a useful step, wholly apart from the debatable question of the identity of energy advocated by Prof. Lodge.

From this point of view, then, we ought to localise gravitational energy as a preliminary to a better understanding of that mysterious agency. It cannot be said that the theory of the potential energy of gravitation exhausts the subject. The flux of gravitational energy in the form above given is, perhaps, somewhat more distinct, since it considers the flux only and the changes in the amount localised, without any statement of the gross amount. Perhaps the above analogy may be useful, and suggest something better.

MEASURING MAGNETIC FIELDS.

BY ALEX. RUSSELL, M.A.

A quick method of measuring the horizontal strength (H) of a magnetic field is very useful in a laboratory or testing room. The following method of measuring H appears at first sight very primitive, but it is capable, in the hands of a careful experimenter, of giving results accurate enough for many practical purposes, and the apparatus required is only of the most ordinary description. In the rough magnetometer test, as done by students in physical laboratories, the apparatus need be only of the most simple description; but this method hardly measures H at a point unless we have the magnet very small, in which case all kinds of errors creep in. The other common methods require special and carefully constructed apparatus.

The instruments required for the method are an ammeter and a small compass needle; one of those sold as "charms"

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for watch-chains is very suitable. The needle is placed at the point where the strength of the field is to be measured, and a long hanging vertical wire, with a current flowing in it, is brought near the needle. When the wire is at a certain distance from the needle on a line drawn through the centre of

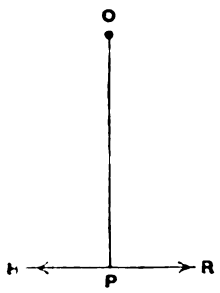

Fig. 1.

the needle perpendicular to its length, the resultant magnetic force is so feeble at the point that the needle rests in almost any position. Let P (Fig. 1) be the point, and suppose the wire to cut the plane of the paper at right angles at O. If the current be flowing upwards and be A amperes, the magnetic

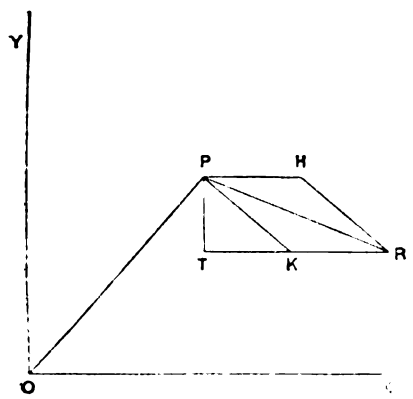

Fig. 2.

force at P due to the current is at right angles to O P in the direction P R, and is equal to $\frac{2A}{10 \cdot OP}$. Then, if the magnetic force due to the current exactly neutralises the field,

$$H = \frac{A}{5 \cdot OP} \text{ C.G.S. units.}$$

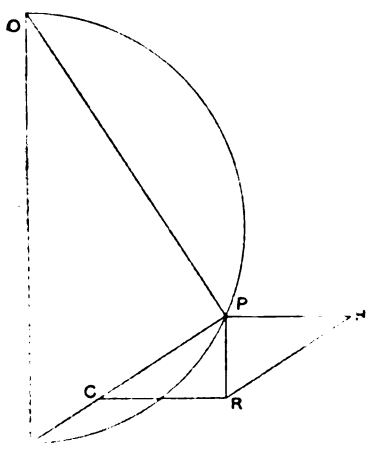

Fig. 3.

The behaviour of the needle at this point is peculiar. On moving the wire from O towards P the needle points towards R, on moving it from P it points towards H. Moving the wire a very little way parallel to R H the needle points towards the wire nearly, and on moving it slightly in the opposite direction the needle points away from the wire. The reason of this can be easily seen by drawing the resultant force at P in the two positions of O by means of the parallelogram of forces.

The case of a uniform magnetic field disturbed by a current flowing in a wire is of special importance. A diagram of the lines of force in this case is given in Clerk Maxwell's "Electricity," Vol. II., plate XVII. As it is useful for our purpose to know the directions of the lines of force nearer the neutral point than he has shown on his diagram, we shall find the algebraical equation to the lines of force and then draw the lines of force through points near the neutral point. The ordinary method of tracing the lines of force, practically, is by means of a small compass, the needle pointing always in the direction of the resultant force and, therefore, always being a tangent to the line of force which passes through the point.

In Fig. 2 let O be the section of the wire by the plane of the paper, and let O X be the direction of the earth's lines. Let (x, y) be the co-ordinates of P, and let the angle P O X be θ. The forces at P are P H parallel to O X and equal to H and P K at right angles to O P and equal to $\frac{A}{5 \cdot OP}$. Let P R be their resultant. Draw P T at right angles to K R, produced. Then for the line of force through P,

$$\frac{dy}{dx} = -\tan PRT = -\frac{\frac{A}{5 \cdot OP}\cos\theta}{H + \frac{A}{5 \cdot OP}\sin\theta}.$$

Also $\cos\theta = \frac{x}{OP}$, $\sin\theta = \frac{y}{OP}$ and $OP^2 = x^2 + y^2$.

Hence $$5H(x^2+y^2)\frac{dy}{dx} + Ay\frac{dy}{dx} = -Ax.$$

$$\therefore \frac{A}{10H(x^2+y^2)}\cdot\frac{d}{dx}(x^2+y^2) + \frac{dy}{dx} = 0.$$

$$\therefore \frac{A}{10H}\log(x^2+y^2) + y = \text{constant},$$

$$\therefore x^2 + y^2 = Me^{-\frac{10Hy}{A}} \quad \ldots\ldots \quad (1)$$

By giving different values to M we get the equations to the lines of force. It is easily seen that $\frac{dy}{dx}$ is infinite whenever a line of force cuts the circle

$$x^2 + y^2 + \frac{A}{5H}y = 0.$$

Hence at all points on this circle, except the neutral point, the needle will point east and west, or west and east.

It is easy to give a geometrical proof of this theorem. The

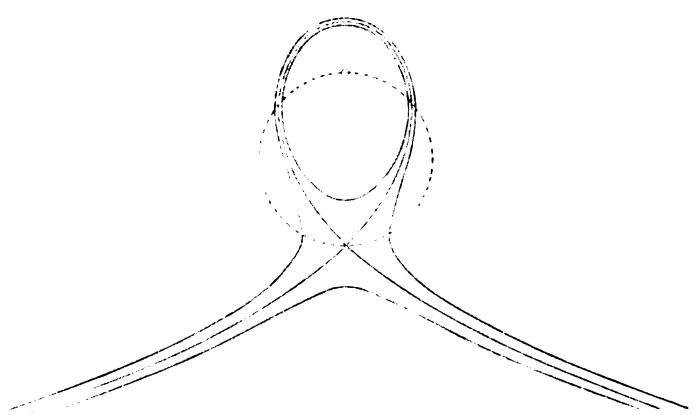

Fig. 4.—Directions of Horizontal Magnetic Force near a Vertical Wire Carrying a Current of 2 amperes.

resultant of the horizontal component of the earth's field and the magnetic force due to the current in the wire at a point coincides in direction with the tangent to the line of force passing through the point. Hence (Fig. 3) if P H and P C be the directions of the forces due to the earth and the wire respectively, and if P R be the diagonal of the parallelogram which

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has P H and P C as adjacent sides, then P R is the direction of the needle. If this is parallel to O A,

$$\frac{OP}{OA}=\frac{CR}{CP}=\frac{5H.OP}{A}$$

$\therefore OA=\frac{A}{5H}=$ constant. Therefore P lies on the circumference of a circle whose diameter is equal to O A. The equation to the line of force through the neutral point is

$$x^2+y^2=\frac{A^2}{25H^2}e^{-2-\frac{10H}{A}y}.$$

This curve is shown in Fig. 4 for the case of A = 2 amperes, and H = 0·18 C.G.S. unit. At points where the lines of force cut the circle shown in the figure, the direction of the lines is parallel to O A.

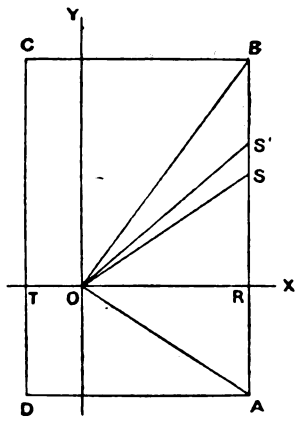

Fig. 5.

We must now consider the effect of the wires leading up to the hanging wire. The simplest case is when the wire is in the shape of a rectangle with its plane east and west (Fig. 5). We shall find an expression for the strength of the field at a point O in the plane of the rectangle, due to a current i (C.G.S. units) flowing in the wire. Let O X and O Y be perpendicular to the sides of the rectangle, and let A R = a, R B = b, and O R = c. Then if F be the strength of the field at O, due

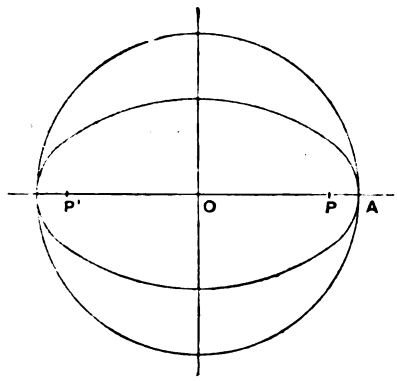

Fig. 7.

to the current in D C, we get by considering the action of an element S S' ($=dy$) of the wire that

$$F=\int_{-a}^{b}\frac{i\,c\,dy}{\{c^2+y^2\}^{\frac{3}{2}}}$$

$$=\frac{i}{c}\left\{\frac{y}{(c^2+y^2)^{\frac{1}{2}}}\right\}_{-a}^{b}$$

$$=\frac{i}{c}\left\{\frac{a}{(c^2+a^2)^{\frac{1}{2}}}+\frac{b}{(c^2+b^2)^{\frac{1}{2}}}\right\}$$

$$=\frac{i}{OR}\{\sin ROB+\sin ROA\}$$

Exactly similar expressions hold for the forces due to the three other sides of the rectangle. Hence the exact formula in this case is—

$$H=\frac{i}{OR}\{\sin ROA+\sin ROB\}+\ldots+\ldots+\ldots$$

If D C is three metres long, B C four metres, O T 10cms., and if O is equi-distant from the two horizontal sides of the rectangle, then an error a little over 1 per cent. is introduced by using the approximate formula $\frac{2i}{OT}$. This error can be got rid of practically either by placing the plane of the rectangle north and south, and finding the point east or west of the hanging wire where the needle points directly towards it, or reversing the current and taking the mean of the two values found for H by the simple formula.

This compass method can also be very instructively applied to measure the field of force inside a flat coil of wire. We set the coil with its plane east and west, and place the compass at the point where we wish to measure the strength of the field, and then pass a small current through the coil (in the proper direction), increasing the current until the needle turns round. Suppose the current in the wire when the field at the point is neutralised is A' amperes, then obviously when a current A flows in the wire the strength of the field at the point due to the current equals H A/A', where H is the horizontal intensity of the earth's field at the point. Similarly we can map out the intensity of the field at other points in the plane of the coil in C.G.S. units.

The case of a circular wire is specially important, and the formula for the strength of the field at a point in the plane of the wire is not so well known as it deserves to be. Let P (Fig. 6) be a point in the plane of the wire, and let O be

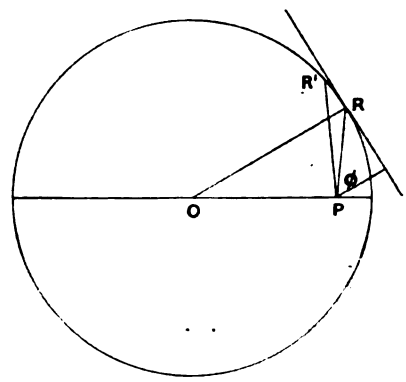

Fig. 6.

the centre and R the radius of the wire. Then if F be the strength of the field due to a current i in the wire,

$$F=\int\frac{i\,ds}{r^2}\times\frac{p}{r}\text{ (usual notation)},$$

$$=\int_0^{2\pi}\frac{i\,d\phi}{r}\text{ since }p\,ds=r^2\,d\phi.$$

Now $r=\sqrt{R^2-a^2\sin^2\phi}-a\cos\phi$, where O P = a,

$$\therefore\ \frac{1}{r}=\frac{\sqrt{R^2-a^2\sin^2\phi}+a\cos\phi}{R^2-a^2}.$$

Hence

$$F=\frac{i}{R^2-a^2}\int_0^{2\pi}\sqrt{R^2-a^2\sin^2\phi}\,d\phi,$$

$$+\frac{ia}{R^2-a^2}\int_0^{2\pi}\cos\phi\,d\phi.$$

Now, if we describe an ellipse which has O for its centre, P for a focus, and 2 R as major axis (Fig. 7), the circumference of this ellipse is equal to $\int_0^{2\pi}\sqrt{R^2-a^2\sin^2\phi}\,d\phi$.

Hence

$$F=\frac{\text{Circumference of ellipse}\times i}{R^2-a^2}.$$

We can thus calculate F at each point by mechanically describing the ellipse by a thread and two pins, measuring the circumference by means of a thread, in the ordinary laboratory way, and then substituting in the formula. The circumference of the ellipse can also be calculated from the formula,

$$\frac{\pi}{2}\{R+\sqrt{R^2-a^2}+\sqrt{4R^2-2a^2}\},\text{ up to }a=0{\cdot}8\,R.$$

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It is a very instructive exercise to map out the strength of a field inside a circular wire by the compass method, and then check the results by means of the above formula.

The method can also be applied to calculating the coefficient of self-induction of a wire bent into a large plane closed curve. The strength of the field very near the wire can be calculated by the formula $\frac{A}{5r}$, and at other points by the compass method.

Suppose F the strength of the field at dS due to unit current, and L the coefficient of self-induction, then

$$L = \Sigma F d S.$$

Hence, since F is known at every point L can be calculated.

ADJUSTABLE CARBON RHEOSTAT.

The Wheatstone Rheostat was probably the earliest form of adjustable resistance, in which a gradual alteration of a resistance was aimed at without any attempt at accurate measurement. In many electrical operations, such as telegraphy,

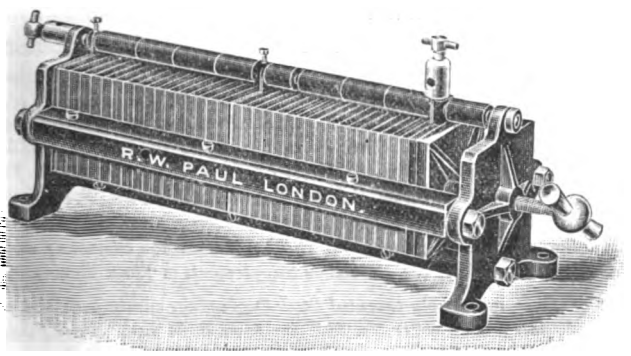

FIG. 1.

definite resistances wound on coils and connected by plugs or switches are used exclusively; but in many modern applications, especially where it is desired to control large currents, adjustable resistances are indispensable. The 10 or 20 point switches, and a number of coils of iron or German silver are often used, but the discontinuity of such an arrangement, to say nothing of the space which it occupies, is an obvious disadvantage.

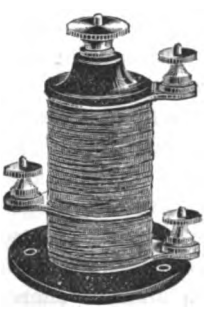

FIG. 2.

The fact that the resistance of carbon blocks alters under pressure was long ago made use of by Brush in his arc lighter regulator, and we have recently received from Mr. R. W. Paul, particulars of two forms of carbon rheostats; the one for heavy currents, and the other for small currents.

The large rheostat shown in the accompanying illustration (Fig. 1) consists of a pile of 40 retort-carbon plates, 3½in. square, by ⅜in. thick. These are held in a metal frame insulated from the circuit, and are secured by a steel screw. The resistance may be varied from 25 ohms to $\frac{1}{25}$th of an ohm, and still lower resistances may be obtained by the use of an intermediate terminal plate. For short periods this rheostat will carry 100 amperes without serious overheating. For laboratory use in the neighbourhood of galvanometers and other sensitive magnetic instruments, the frame and fittings may be made of gun metal. Such a rheostat depends to a certain extent upon the elasticity of the carbon plates.

For smaller currents another form (Fig. 2) of carbon is used, viz., Varley's carbonised cloth, 150 sheets of stout cloth are built into a pile 1⅝in. in diameter, 2½in. high, with a hole down the centre ½in. in diameter. The pressure is applied by a screw passing down the centre. The resistance between the outside terminals varies (*a*) with the degree of "cementation" of the cloth, (*b*) with the pressure applied to the column by the milled nut. When the nut allows the elasticity of the sheets to extend the column to a length of 2½in. the resistance is 10 to 15 ohms, the carbon being well cemented. When the nut is turned so as to give the maximum safe compression, *i.e.*, length of column 2in., the resistance is approximately $\frac{1}{10}$th of an ohm. By using a different quality of carbonised cloth in which the process of carbonisation has not been carried so far, resistances of 20 to 500 ohms may be constructed, the instrument being of the same dimensions. Owing to the springiness of the cloth, ordinary shaking or jarring does not perceptibly vary the resistance. As in the large rheostats, an extra terminal is placed at about one-third from the bottom of the pile, so as to reduce the above resistances to one-third or two thirds of their value. With a 10 ohm rheostat, that is to say, with an instrument whose maximum resistance is 10 ohms, a current of 4 amperes *may* be passed, but it becomes too hot to hold when it is dissipating about 160 watts.

FUSION AND VOLATILISATION OF VARIOUS SUBSTANCES IN THE ELECTRIC ARC.*

BY H. MOISSAN.

When we have wished to condense the vapours of difficultly volatilised bodies at a high temperature, we have employed a metal tube, cooled internally by a current of water, and in these experiments we have used a U-tube of copper, of 15mm. diameter conveying a current of water at a pressure of 10 atmospheres. The bend of the U-tube was introduced into the electric arc, over the little crucible containing the substance to be volatilised. By means of the arrangement adopted the vapours condensed in abundance on the cold tube. A fragment of copper, weighing 103 grammes, was placed in the crucible, and a current of 350 amperes, at a pressure of 70 volts, was passed for five minutes. Brilliant flames, 4 or 5cm. long, accompanied by dense yellow fumes, poured from the crucible, and an abundance of metallic copper condensed in the U-tube. The experiment repeated, but with silver instead of copper, gave a mixture of amorphous silver and molten globules in the cold tube. Platinum and aluminium were also quickly volatilised and condensed in metallic globules in the tube. From tin a dense incrustration of the oxide was obtained.

With a current of 380 amperes at 80 volts, the volatilisation of silicon was obtained, and globules of this element, readily soluble in nitric and hydrofluoric acid, collected upon the condensing surface of the tube. With the same current at the same pressure, carbon placed in the crucible, in the form of large lumps, quickly became changed into *graphite*; and, at the end of the experiment, transparent particles of a chestnut colour were found on the cold tube. Mr. Berthelot has already discovered the existence of such a chestnut coloured carbon of low specific gravity. With a current of 400 amperes lime was volatilised, and an amorphous powder of calcic oxide was deposited. Magnesia, which is more difficult to volatilise than lime, gave a similar result. Mr. Daubrée has remarked that the carbon now found in organic compounds was originally combined with metals in the state of metallic carbonates. The electric furnace seems well to reproduce the conditions of that remote geological period. It is probable that these compounds exist at a high temperature in some of the stars.

Electrical Communication with Lighthouses.—The Royal Commission on electrical communication with lighthouses and lightships have now commenced their inspection of lighthouses and lightships on the South and East Coasts of Ireland and the Isle of Man. They intend to visit Bangor and Belfast Lough, after inspecting the "South Rock" and "Skull Martin" light vessels from Her Majesty's ship "Enchantress."

* Abstract from *Comptes Rendus*.

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THE ELECTROLYSIS OF STEAM.

By far the most striking and important point involved in Prof. J. J. THOMSON's Paper on "The Electrolysis of Steam," which we reprint elsewhere, and which was read before the Royal Society last March, is the fact that the elements hydrogen and oxygen exhibit either an electro-positive or an electro-negative property, according to the length and character of the spark which is passed through the super-heated steam. When the electric discharge is of the nature of an arc, or continuous stream, the electrolytic hydrogen is evolved at the *positive* electrode, while, when that element appears at the *negative* electrode, the discharge shows all the characteristics of a spark, though it would appear that the hydrogen may be evolved at either of the electrodes when there are separate sparks passing through the steam. The whole phenomenon is enveloped in mystery, and the explanation offered by the author of the Paper can only be regarded as a tentative one. Does the atom-charge of the dissociated hydrogen really depend on the state of electrical stress under which it is liberated, and on the time which has elapsed since the passage of a previous discharge? Does an electrical discharge through an insulating gas really metamorphose the gas into a temporary and very unstable isomer or allotrope, which enables conduction readily to take place? If so, the explanation of the reversed electro-chemical property is not a difficult matter. But, on the other hand, the assumption that these things do occur calls up innumerable difficulties. For the complete reversal of the atom charge under electric stress could only occur, according to existing notions, under a complete reconstruction of the atom itself, which postulates more than can be readily granted by our scientific imagination; while the assumption that the passage

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of the arc through steam surrounds the discharge with a modified gas in the form of negative hydrogen *mixed* with positive oxygen can only be accepted, as far as we are able to gather, on the ground that it suits the particular phenomenon we are considering.

The test experiments by which Prof. THOMSON discovered that oxygen enveloping an arc becomes positively charged, and hydrogen negatively, deal, of course, with atoms of these elements in the aggregate; and it seems probable from them that electrification of the gas in bulk is the key to the solution of this problem. It seems possible, however, that, under certain conditions in which the mean free path of the ion atoms would be sufficiently long, the reversal of the gas at the electrode may be caused by the repulsion of the electrified gas from the electrode at which it is dissociated, and its ultimate liberation at the opposite electrode. Since this would only occur under certain magnitudes of stress, and would take place simultaneously with both ions, the supposition would not necessarily be inconsistent with CLAUSIUS's modification of GROTTHUS's hypothesis of electrolysis. It is interesting to notice that in the same number of the *Proceedings* of the Royal Society with Prof. THOMSON's Paper, there is a Paper by Dr. ALEX. SCOTT "On the Composition of Water by Volume," in which an attempt has been made to show that the volumetric proportions of hydrogen to oxygen in water is greater than two to one. Inasfar as the correctness of this assumption would affect the complexity of the molecule of water (and of steam), it might throw some light upon Prof. THOMSON's results; but it seems probable that the discrepancy arises from some difference between the purely physical properties of the hydrogen and oxygen, or from the formation of ozone in the latter.

MUNICIPAL TELEPHONY.

As we mentioned some little time ago, a Special Committee of the Glasgow Town Council was appointed to consider the *pros* and *cons* of establishing a municipal telephone service within the bounds of what is now frequently called "Greater Glasgow," and we ventured to suggest that municipal telephones might possibly prove, after due consideration and experiment, to be the best way out of the telephone *imbroglio* which at present exists in this fortunate isle. At a meeting of this Special Committee on Monday last it was unanimously decided to recommend that the Town Council should apply to the Postmaster-General for a telephone licence. Glasgow has always favoured municipalisation, and the experiment of municipalising the telephones, should it ever be put into practice, will, therefore, be carried out on congenial soil. Some forty years ago the Glasgow Corporation bought up the existing water companies and constructed immense works for the purpose of bringing water into the city from Loch Katrine, some thirty-four miles off, something like £3,500,000 having been spent upon the enterprise up to date. In 1869 the gas works were bought up. At the beginning of last year the electric light works were purchased, and on July 1st next the Glasgow tramway system will also be taken over and worked by the Corporation. The addition of municipal telephony to such varied and extensive duties should not, therefore, prove a fatal tax upon the civic energies of Glasgow. At the meeting of the Committee on Monday an exhaustive memorandum dealing with the whole of the subject of telephony was submitted by the convener. The case for a good telephone service is sufficiently strong without the addition of what may be termed special pleading. Because telephone rentals in Holland and Scandinavia are of the order of £3 a year it does not follow that £10 is an extravagant charge in the United Kingdom. Such statements require to be accompanied by data as to the efficiency of the systems and the general cost of labour and living in the countries mentioned. The convener further mentioned that reliable and detailed estimates had been prepared, showing that the latest and best telephone system could be laid down in Glasgow within the municipal radius for a capital expenditure of about £15 per subscriber, and that a £5 annual rental was feasible. We trust these anticipations may be realised in actual practice; but it must be remembered that most engineering estimates are notoriously over sanguine.

It is, of course, advisable that certain public services should be carried out by a public body, and not even the most inveterate individualist can offer serious objections to the municipalisation of the water, fire, police, sanitary, and street lighting services. A *doctrinaire*, indeed, could easily prove to demonstration that whilst street lighting pertains to a municipality private lighting does not; but the plain business man would admit that whoever undertakes one should undertake both. The encouragement of unlimited talk is, however, a considerable extension of the sphere of municipal activity, and we shall not be at all sorry to see the first large scale experiment carried out at a safe distance across the border.

REVIEWS.

Electrical Measurements and other Advanced Primers of Electricity. By EDWIN J. HOUSTON, A.M. (New York: W. J. Johnston Company, Times Buildings. London: Whittaker and Co.)

The Elementary Primers, upon which this book is an advance, were written at the time of the Philadelphia International Electrical Exhibition, and were designed to aid a public quite unacquainted with the principles of electrical science. The present series of Primers, although an advance upon the first, are of a strictly popular nature, and are written for a public which is assumed to have assimilated a certain amount of electrical knowledge—at least, in so far as the applications of electricity are concerned—in the interval. The work is essentially American in almost all its interests and in the style in which its matter is arranged; but it will no doubt be read with profit by an English public. The ground covered is not so wide, but the character of the Primers is nearly the same, as the series of Primers which are known to our readers; and we are glad to see that the practice of adding to each Primer the name of some text-book which bears particularly on the subject has been faithfully followed. The greater part of the book is taken up with electrical distribution of power and the theory and practice of alternating currents, which are dealt with in a clear and simple style, and are brought up to date. Perhaps the most interesting Primer in the series is No. IX., on high-frequency currents, which deals with the researches of Tesla and others on this subject, and is copiously illustrated.

Electric Lighting and Power Distribution. Part II. By W. P. MAYCOCK. (London: Whittaker and Co.)

We have already reviewed Part I. of this book in *The Electrician*, Vol. XXX., p. 602. Part II. deals with more practical matter, and contains a very good descriptive chapter on modern dynamos and alternators. The succeeding chapter on motors, is also well written. Dynamo theory is continued in Chapter X.; but the evident desire to maintain a very elementary style has led the author to generalise in a rather misleading manner. For example, we are told that the characteristic curves of "all series machines are more or less alike," and the student is led to believe that the characteristic of a series dynamo is in all parts an ascending curve. What unconscious humour there is in the footnote to page 295: "Many writers confuse the parallel-series and the series-

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parallel arrangements." Unhappy writers! but we must own to being among their number. If such terms as "parallel-series" and "series-parallel" are required by the syllabus of examinations of the august Guild for which the book is prepared, it is quite time that the requirement ceased. On the whole, this second part is considerably better than Part I.

Premiers Principes d'Electricite Industrielle. By PAUL JANET. (Paris: Gauthier-Villars et Fils.)

This work is the reproduction, in an extended form, of a series of lectures which were delivered by the author at Grenoble, under the auspices of the Municipality, in the early part of 1892. As a popular treatise on electro-technics the book should find numerous readers; for, while the style is clear and the matter is simply rendered, popular treatment has not been attempted by means of misleading generalisations or that slurring over of details which we find in too many of the works which appeal to a non-scientific public. Here is interesting and instructive reading combined; and even a serious student of technical electricity may do himself good by perusing it. The various chapters deal with secondary cells, dynamos, alternators, transformers, and polyphase currents, with an introduction giving just enough theory to knit the practical parts together.

Electricity and Magnetism: A Popular Introduction. By S. R. Bottone. (London: Whittaker and Co.)

The author of this little book writes that its object "is to present an easy and attractive introduction to the sciences of electricity and magnetism. The work is not intended as a text-book. . . . Care has been taken to impart exact knowledge, that will not have to be unlearnt." We quite support the author's intention not to offer this work as a text-book; and when we read of the care which has been expended in making the book exact, we regret that such care should have been in so many cases unsuccessful. In other words, we do *not* agree that the knowledge which is imparted is exact, or that it would not have to be unlearned. Witness the following:—On page 15 we read: "An attentive consideration of these lines of force, as thus depicted by the iron filings, will lead us to the conclusion that the influence of a magnet, like that of all radiating forces, must, from the very nature of things, decrease *inversely as the square of the distance*." The italics are not our own, but the author's. Is it possible to crowd together more errors into one small sentence than are crowded into this? An attentive study of iron filings can never lead to an exact mathematical law; if it could, the law of inverse squares would not apply to the case cited. Magnetism is not, as Mr. Bottone infers, analogous to "all radiating forces" in this respect; and his inference, from "the very nature of things" is illogical and superfluous. The attribution of terrestrial magnetism to ferruginous soils, on page 21, is purely a gratuitous assumption, there being no evidence of any such cause. According to Mr. Bottone, the modern theory of electricity, "generally known as the *molecular* or *mechanical* theory," is one in which "the fundamental idea is that during excitation, whether by friction, percussion, chemical action, or motion before the poles of a magnet, the normal condition of a body is altered, its molecules are set in motion, probably rotary, with the axes of rotation all in one direction, or "polarised," and this motion produces a kind of strain between molecule and molecule, in one direction in the excited body, and in the opposite direction in the exciting body." We do not know whose "modern theory" all this is supposed to represent; but, whatever may be its origin, we have no hesitation in saying that it is utterly erroneous and unscientific. These, and many other statements in the book, the reader must unlearn when he passes from the "introduction," offered by Mr. Bottone, to the study of the real science of electricity.

A Guide to Electric Lighting. By S. R. BOTTONE. (London: Whittaker and Co.)

The second edition of this little book lies before us. Ten thousand of "the public" have paid their shilling, and have been guided into the mysteries of electric lighting. What is precisely that this public may have desired to know is as much of a mystery as anything electrical is to it. Perhaps it was to satisfy its innate love of being mystified that ventured along this way. If so, the information on page of the guide-book, that "electricity itself is but another form of motion, which requires power to produce it," ought serve the purpose very well! Again, we can fancy some one asking the guide, "But what *is* an ampere-turn?" which the guide makes answer (page 45), "By ampere-turn is meant the number of turns of wire equivalent to a single turn carrying one ampere." And with a murmur of approval, and many a knowing nod, the crowd would then pass along to see "the next thing." And the things to be seen are very curious—so antiquated, so utterly unlike the electric lighting machinery the public sees nowadays, that it must feel gratified at the sight. Here, on page 14, is a Leclanché cell, with pages of description to follow; but there is not time to ask what this has to do with the subject. Wilde's dynamo is, of course, to be seen—it always is in such books; and with it the arc lamps of Serrin, Archereau, and Browning. What shall all these things have their decent burial? Electro-motors are taken in on the way, though they have little to do with electric lighting; and we are introduced to a "law" of the electro-motor which, to us, is quite new, namely, that "when the magnetic saturation-point of the iron is reached the increase in efficiency in the machine is not proportional to the increase in current." There is no mention of the discoverer of this law; and the negative form which it assumes is a little discouraging, but still, as Carlyle would say, it is "significant of much."

Berechnung Elektrischer Maschinen. By ERNST H. GEE. (Oldenbourg: Munich.)

This handbook, which has now reached its second edition, deals with the principles underlying the electrical design of dynamos in a manner at once fresh and interesting, which is described by its author as an amplification of the universally used Hopkinson method. This latter only enables the designer to fix the winding of the machine, after assuming the magnetic circuit, to a degree of accuracy greater than is practically necessary; while the author's method goes a step further back and assumes first the number of poles, and from this determines the output per pole, and thence the space required for winding and the volume of iron. Assuming, then, a relation between the construction of inducing and induced magnets the winding and volume of iron are determined, and hence the whole machine. These principles are elucidated in a short introductory chapter of fourteen pages, and the rest of the small volume is devoted to concrete examples of every variety of machine for both direct and alternating currents, and also for transformers. The work is one which would be of value to students of dynamo design, and affords an interesting example of the German practice, which, as is well known, differs so widely from that which finds favour in this country.

THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 262.)

Some of the methods of preparing filaments will now be described. In spite of all the work that has been done by experimenters during the last ten or fifteen years with a view to providing something new and better, it remains a fact that the original process of Swan's, that of parchmentising cotton thread by sulphuric acid, remains to this day one of the best, if not the best and most easily worked of any. It will, therefore, be described first.

The raw material in Swan's process is pure cotton loosely spun into a thread, such as is sold for knitting. It is usual

* Abstract from a book to be published shortly by *The Electrician* Printing and Publishing Company (Limited). All rights of re-publication reserved.

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in the first instance, to clean the thread by boiling it in soda or ammonia, to take out any grease which may be present in it and which would prevent the sulphuric acid from acting on those parts which would be thereby protected. It must, however, be thoroughly washed afterwards, in order to remove all traces of the alkali, and then dried.

It is, after all, an open question if the above process of boiling in alkali does any good, provided that the cotton is as clean as it can be obtained in the first instance, for in spite of the process, there are often found to be places in the thread upon which the acid will not act, or rather upon which it will not act in the time allowed. Sometimes these places are very small, and can only be seen by examining the parchmentised thread very closely, while at other times they will extend for several inches along the thread, and occur at short intervals. No satisfactory explanation of these acid-proof, or partially acid-proof, sections has yet been given, or, at any rate, no satisfactory remedy has been proposed.

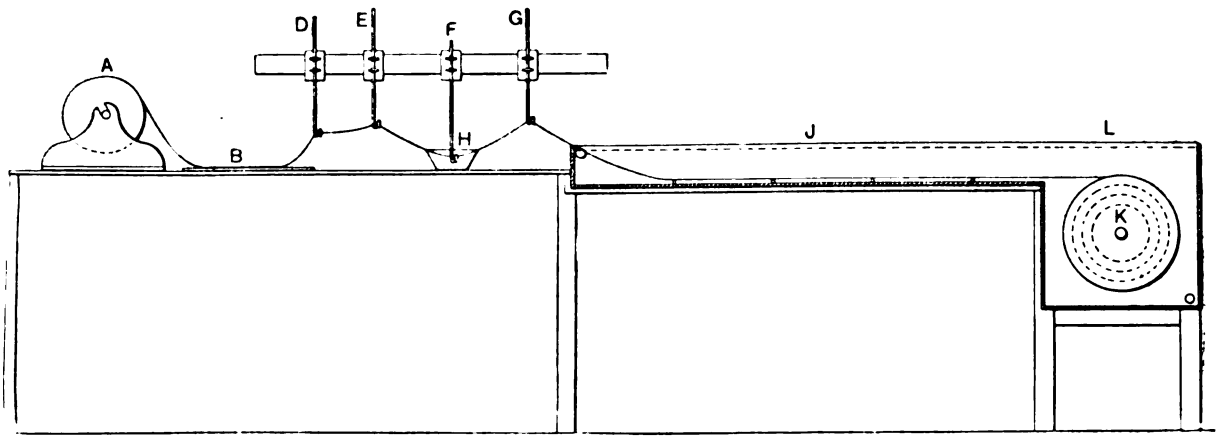

FIG. 1.

When dry, the cotton thread is wound on a drum, and from the drum it is unwound and drawn through a dish of sulphuric acid of the required strength, whence it is drawn into water and wound on another drum which is preferably wholly under the water.

Fig. 1 shows an arrangement which the author has found to work very well. At the left-hand end is seen the drum A, upon which the thread is wound in the first instance. K is the drum on which the thread is ultimately wound and which draws it along. The thread has to be guided in its passage from one drum to the other, so as to pass for the right length of time through the acid and then into the water. It must be remembered, that the action of the acid continues from the moment when the thread enters the acid until it enters the water, though the thread is only actually under the acid in the dish for a short time, after which it passes through the air until it reaches the water.

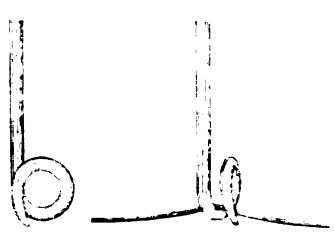

FIG. 2.

In order to guide the thread with the minimum of friction, glass rods with an open loop formed at the end may be used, (Fig. 2), the thread passing through the loop. The advantage of this form is that the thread may be put into the loop while in motion without having to thread the end through first. A number of blocks, D, E, F, G, Fig. 1, are mounted on a bar about eighteen inches above the bench, each capable of sliding lengthwise along the bar. To each block one of the glass guide-rods is attached so that it may slide up or down and be held at the required height by a clamp. Between the left-hand drum A, and the first guide-rod D, a sheet of glass B, is laid on the bench. H is a dish containing the acid. J is a lead-lined trough of some six feet in length, terminating in a tank L, which contains the winding drum K, driven from overhead by a band.

In starting the apparatus, sufficient thread is wound off the drum A, so that the end will reach to K. More thread is then wound off A, and laid zig-zag fashion across the glass-plate B. The first length of thread is then dropped into the glass guide-rods and the end is looped on to a projection on the edge of the drum K as it revolves. The thread is, therefore, wound on to K and drawn along from off the plate B. One of the guide-rods, say F, is now lowered so that it depresses the thread below the surface of the acid in the dish H. On emerging from the acid, the thread passes up through the guide G, and then drops by its own weight into the water in the trough J. The object of the trough J is that the thread may be examined easily in order to see if it is receiving the proper amount of treatment. It can be best examined while passing along this trough, as it is readily seen in the water against the lead lining of the trough. On coming out of the acid dish, the thread has a transparent and bright appearance, like a string of jelly. When it enters the water it is immediately changed from the transparent to a semi-opaque condition. It is at this point, after entering the water, that it must be constantly watched to see if it is receiving the proper amount of treatment. If it is not being done sufficiently, it will have a core of unconverted cotton running through it continuously or in patches. If it is receiving the proper amount of treatment, it will appear as a semi-opaque homogeneous thread. On the other hand, if the treatment is too long, the thread will probably break. It is, therefore, necessary at starting to give it less than the proper amount of treatment. The acid dish can then be moved gradually further back, so that the thread has a longer distance to travel from the acid to the water. If more treatment than can be given by this means is required, the speed of the drum K must be reduced. When the apparatus is adjusted, the acid dish, the edge of which is ground level, is covered by pieces of sheet-glass so that the acid is not exposed to the air, only a small opening being left just where the thread enters and leaves. As the thread is drawn along, it is of course taken up off the glass plate, and the attendant must take care to have more thread wound off the drum and laid across the glass plate before the last lot is used up, or a breakage will occur. Another plan is to drive the drum A as well as K by power. The thread is then unwound from A as it is wanted. The former method, however, gives less trouble. By the method of laying out the thread in zigzag rows on the glass plate, the attendant has sufficient time to examine the thread as it passes along the trough, and keep the apparatus working properly. A sheet of glass is required, because the fine fibres of the loosely-spun thread are apt to catch if laid out on an ordinary wooden bench, unless it is of hard polished wood. The slight momentary strain produced in this way is often sufficient to cause a breakage. In order to still further reduce the strain, porcelain or glass pulleys

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driven at the proper speed may be used instead of the glass guide-rods (Fig. 2). The latter, however, are much simpler, and answer the purpose quite well. One girl can easily work the apparatus. There is a supply of water at the bottom of the tank L, with an overflow at the end of the trough J. Fresh water is thus always coming in by the drum, and passing along the trough. The strong acid carried into the water by the thread is thus washed out without getting far along the trough.

The strength of the acid is an important consideration. A specific gravity of 1·64, as recommended by Mr. Swinburne, works very well. This is a little stronger than that mentioned by Swan in his patent. The temperature at which it is used should be from 60° to 70°F. A large quantity of acid should be made up to the required strength and drawn off in small quantities as required.

It is a curious fact that the finer threads are more easily worked than the larger, and are less liable to breakage. A much shorter immersion in the acid is required, as a rule, for the larger sizes of thread than the smaller. The speed at which the thread must travel is from twelve to twenty-four feet per minute, and the length of thread under acid (from where it enters the acid to where it enters the water) will be from twelve to thirty-six inches. The actual time, therefore, during which the acid is acting on the thread will be from two and a-half to fifteen seconds, according to the quality and size of the thread and the tightness to which it is spun.

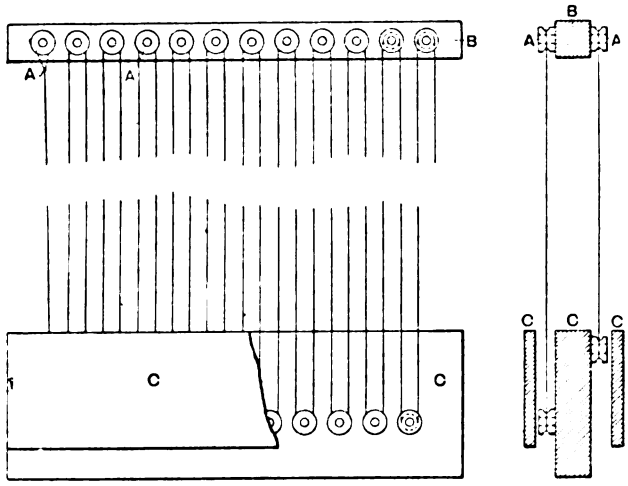

Fig. 3.

Guide-rods may be arranged in front of the winding-drum K, so as to gradually move the thread along the length of the drum and ensure it winding evenly. This, again, is an unnecessary refinement. A glass rod fixed to a piece of wood, which can be laid across the trough and moved by hand every now and again, is quite sufficient. It does not matter if the thread is wound on the drum in several layers, as it is easily wound off afterwards, and the washing of several layers does not take much longer than a single one. If only one layer is wound on the drum, the number of drums and washing tanks is multiplied, and time is lost in changing the drums more frequently. The drum K may be made with a wood spindle and ends, and covered with copper gauze, which allows of a more rapid and thorough washing of the thread than a solid surface would do. When a drum is filled it is lifted out of the tank L and removed to another tank, in which the thread is further washed by a continual circulation of water. In twelve hours or so all traces of acid will have been removed from the thread, which is then ready for drying.

The parchmentised thread quickly dries on exposure to dry air, and in doing so it hardens and contracts. It is consequently necessary to take it off the drums on which it has been washed and hang it up in order that it may dry evenly and straight. A convenient method of drying is shown in the accompanying sketch, Fig. 3.

A number of bars of wood are fixed parallel to each other, eight or nine feet above the floor of the drying-room and about two feet apart. On each side of these bars, B, are secured a number of porcelain insulators, A A, at intervals of a little less than their own diameter, about two inches. Immediately below the bars is fixed on the floor a framework consisting of three boards set up edgewise, the two outer ones not reaching to the floor by two inches or so, except at the ends, the space between the two outer boards and the centre one being a little more than the width of the insulators. In order to dry the parchmentised thread, the drum on which it is wound is taken out of the washing tank and set in a stand so that it can be turned round. One operative takes the end of the thread and ties a loop on it, and standing on a pair of steps, hangs the loop on the farthest insulator. A second girl unwinds the drum, and a third one takes the thread as it comes off and hands it to the first one, who hangs it again over the second insulator, while she (No. 2) proceeds to hang another insulator in the loop thus formed and lower it between the boards, the length of the loop being so adjusted that the

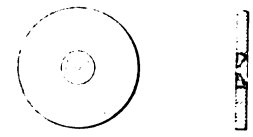

Fig. 4.

insulator hangs at the bottom of the outside board. This operation is continued until the whole length of the parchmentised thread is hung up, with a weight on every loop to keep it stretched. As the thread dries it contracts and raises the weights hanging in the loops to nearly the top of the boards. When dry the thread has become again more transparent and has somewhat the appearance of catgut. It is then taken down and wound on a reel, and is ready for the next process of cutting to size. The boards, C C C, are for the purpose of preventing the weights from falling off the thread and the loop from twisting on itself. When taking the thread down the weights are easily shaken off. The outside boards, C C, are fixed above the ground so that the weights can be got out easily if they fall between the boards. This method of drying insures that the thread all along gets the same tension. For thick thread it may be necessary to use heavier weights than for the smaller sizes.

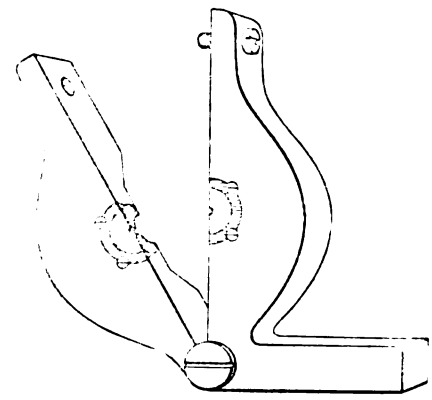

Fig. 5.

Another method is to have porcelain pulleys instead of the insulators, and the bottom ones fixed as well as the top. The thread is then wound up and down, and one weight only hung upon the end. This method, however, puts on a varying strain owing to the friction in the pulleys, and some lengths will be pulled tighter than the others. Besides, the thread, as soon as it begins to get dry, stiffens, and will not readily pass over the pulleys. In the first method it will be seen that the thread is not required to move past the pulleys as it contracts.

The chemical action of this parchmentising process is remarkable, inasmuch as the parchmentised thread appears to retain the same composition as the thread ($C_6H_{10}O_5$), from which it is made, though in appearance it is an absolutely different substance. There is, however, an increase in weight equal of about 8 per cent. The substance so produced is

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called amyloid, and, as will presently be explained, it can be produced by other methods. The amyloid thread produced as above has a rough and uneven surface, and it must be shaved down and made even before it is fit for use. This cutting down is accomplished by pulling the parchmentised thread through sharp-edged draw-plates. As there are often lumps on the thread, it has to be drawn through several sizes of draw-plates in order to remove these lumps before it is passed through the smaller sizes, which will shave it along its whole length. If it is drawn through too small a plate at first, it will break when the thick parts reach the draw-plate. Steel draw-plates can be used, but the cutting edge will very soon become blunt. Jewelled plates are therefore generally used, and even the hard stones used in these frequently require sharpening. The size of thread parchmentised is proportioned as nearly as possible to the size necessary for the particular filaments required, so that there shall be no more cutting down than is necessary for obtaining even filaments.

The draw-plates used for the larger sizes of thread may be similar to the ordinary jewelled wire draw-plates, but with a sharp-cutting edge, Fig. 4. For the smaller sizes, however, below about twenty mils, it is necessary to use split draw-plates, owing to the difficulty of threading them. Fig. 5 is an illustration of a split draw-plate. The ends of the larger sizes of thread can be easily pointed with a knife, and pushed through the circular draw-plates, and pulled through at first with tweezers. It is, however, very difficult to do this with the smaller sizes, and it is, therefore, better to use the split form. The circular form is used whenever possible, as it costs very much less than the split one. The thread must be drawn through the plates as regularly as possible, and for this reason the plate is fixed upright on a bench, and twelve inches or so behind it there is a wooden drum turned by power. A couple of feet or so of the thread is pulled through the die by hand and then turned once or twice round the drum, which then does all the pulling in a steady and even manner, so that the thread is much less likely to break than if it is drawn by hand. A guide should be fixed both in front and behind the draw-plate, and in line with the hole, so that the thread is always drawn through perfectly at right angles to the front surface which contains the cutting edge. If the thread is not drawn through straight it will be cut unevenly and of an oval section instead of circular. When the jewel becomes dull, and will no longer cut properly, it can be sharpened and made as good as new again, though it will by the process be made larger in the hole, and will only serve for a larger size of thread than before. The thread must be passed through several sizes of plate each a little smaller than the last. The amount cut off by each plate should not be more than about 5 per cent. of the diameter of the thread, except, perhaps, at starting, when lumps only are being cut down. This process of cutting down when properly carried out gives the thread a smooth, polished surface, and makes it perfectly circular. It is then ready for being blocked for carbonisation.

(To be continued.)

THE ELECTROLYSIS OF STEAM.*

BY J. J. THOMSON, M.A., F.R.S.

It is well known that steam is split up into hydrogen and oxygen when an electric discharge passes through it. A very careful examination of the laws of this phenomenon was made more than 30 years ago by Perrot ;† as his results are very remarkable, and seem to be not at all well known, I will describe, as briefly as possible, his apparatus, and the results he obtained with it. The spark passed between two platinum wires sealed into glass tubes, which they did not touch, except at the places where they were sealed ; the open ends of these tubes were about 2mm. apart, and the wires terminated inside the tubes at a distance of about 2mm. from the ends. The other ends of these tubes were inserted under test tubes in which the gases, which passed up the tubes, were collected. The air was exhausted from the steam vessel, and the water vapour, through which the discharge passed, was obtained by heating the water in the vessel ; special precautions were taken to free this water from any dissolved gas. The stream of vapour arising from this water drove up the tubes the gases produced by the passage of the spark ; part of these gases was produced along the length of the spark. Part of the gases so collected have been decomposed by causes which would not be affected by reversing the electrical conditions of the electrodes, *e.g.*, by such causes as the heat produced by the sparks. We should not expect to find any simple relation between the amount of decompositions from these causes and the quantity of electricity which had passed through the gas. The hydrogen and oxygen produced by such causes would, however, be driven up the tube in chemically equivalent proportions, and could therefore be eliminated by sending a spark through these gases, when they would recombine and form water.

When the sparking had ceased, the gases which had collected in the test tubes were analysed ; in the first place they were exploded by sending a strong spark through them ; this at once got rid of the hydrogen and oxygen which existed in chemically equivalent proportions, and thus got rid of the gas produced by heat, &c., along the length of the spark. After the explosion, the gases left in the tubes were the hydrogen or oxygen in excess, together with a small quantity of nitrogen, due to a little air which had leaked into the vessel in the course of the experiments, or which had been absorbed by the water. The results of these analyses showed that there was always an excess of oxygen in the test tube in connection with the positive electrode, and an excess of hydrogen in the test tube connected with the negative electrode, and, also, that the amounts of oxygen and hydrogen in the respective tubes were very nearly chemically equivalent to the amount of copper deposited from a solution of copper sulphate in a voltameter placed in series with the discharge tube. In Perrot's experiments the excess of hydrogen appears at the negative electrode, the excess of oxygen at the positive ; Ludeking* confirmed this result.

As these results bear very closely on the method by which the discharge passes through gases, and seem to have special reference to a view which I have long held, that the discharge through gases is accompanied by chemical changes analogous to those which take place in electrolytes conveying currents, I was anxious to repeat and, if possible, extend them.

The form of apparatus which I now use, though similar in its main features to that used by Perrot, differs from it in some respects. Before describing the apparatus in detail, I will indicate the chief points of difference between it and Perrot's.

One source of doubt in Perrot's experiment seemed to me to arise from the proximity of the tubes surrounding the electrodes to the surface of the water. These tubes were narrow, and, if they got damp, the sparks, instead of passing directly through the steam, might conceivably have run from one platinum electrode to the film of moisture on the adjacent tube, then through the steam to the film of moisture on the other tube, and thence to the other electrode. If anything of this kind happened, it might be urged that, since the discharge passed through water in its passage from one terminal to the other, some of the gases collected in the tubes might have been due to the decomposition of the water and not to that of the steam. To overcome this objection, I have (1) removed the terminals to a very much greater distance from the surface of the water, and placed them in a region surrounded by a ring burner, by means of which the steam can be heated to a temperature of 140° or 150° C. ; (2) I have got rid of the narrow tubes surrounding the electrodes altogether by making the tubes through which the steam escapes partly of metal, and using the metallic parts of these tubes as the electrodes.

Though I prefer this method of arranging the electrodes as being somewhat more convenient than Perrot's form of the experiment, in which the electrodes were wires surrounded by glass tubes, I have repeated the experiments described below, using wire electrodes ; the results, however, were precisely the same as those obtained when the tubular electrodes were used. One great advantage of these tubular electrodes is that the quantity of metal in them is large enough to keep them quite cool during the discharge ; while, when wire electrodes are used the end of the negative terminal becomes red hot if any considerable current passes through the steam.

Instead of following Perrot's plan of removing the mixed gases from the collecting tubes, and then exploding them in a different vessel, I have collected the gases on their escape from the discharge tube in graduated eudiometers provided with platinum terminals by means of which the mixed gases were exploded *in situ* at short intervals during the course of the experiments. This plan avoids the trouble, waste of time, and risk of error incurred in moving the mixed gases from the collecting tube to the eudiometer. Its greatest advantage, however, is that it enables us to see with very little delay at which terminals the excesses of hydrogen and oxygen are appearing.

* Abstract of Paper read before the Royal Society, March 9, 1893.
† *Annales de Chimie et de Physique* (3), Vol. LXI., 1861, p. 161.

* *Phil. Mag.* (5), Vol. XXXIII., 1892, p. 521.

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Description of the Apparatus.

I will now pass on to describe the form of apparatus which, after many trials, was found to be the most convenient. This is represented in Fig. 1. H is a glass bulb, 1·5 to 2 litres in volume, containing the water which supplies the steam. A tube, L, about 0·75cm. in diameter and 35cm. long, is joined on to this. In many cases this was *fused* directly on to the bulb; I do think, however, that this is necessary, and I have found no ill-effects arise from making this connection by placing a rubber stopper in the prolongation of the bulb, and pushing the tube L through a hole in this stopper, care being taken to push the tube right through the hole.

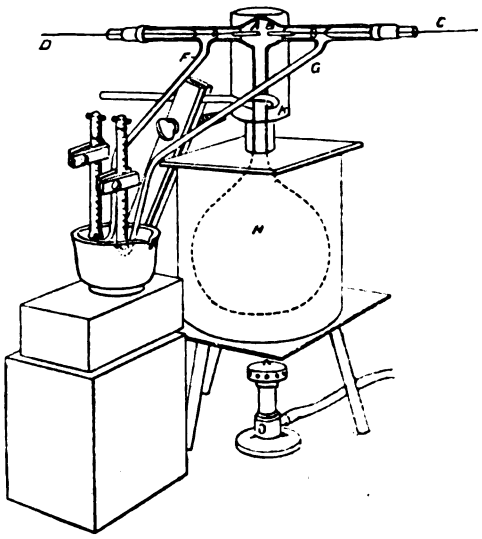

FIG. 1.

The top of the tube L is fused on to the horizontal discharge tube C D; this tube is blown out into a bulb in the region where the sparks pass, so that when long sparks are used they may not fly to the sides of the tube. The top of the tube L, near its junction with C D, is encircled by a ring burner K, and this part of the tube is surrounded by an asbestos case; by these means the steam may be superheated to a temperature of 140° to 150°C. The details of the electrodes between which the sparks pass are shown in Fig. 2. For the metal parts *a b* it is necessary to use some metal which is not oxidised by the steam, as a very small amount of oxidation would be sufficient to render the results nugatory. I have used as the electrodes, (*a*) brass tubes thickly coated with gold with their sparking ends carefully rounded off, or (*b*) tubes made by winding thick platinum wire up into a coil. These tubes are placed in pieces of glass tubing, *e e*, to hold them in position. To faciliate the expulsion of air from the apparatus, it is desirable that the metal tubes should not fit so tightly into the glass ones as

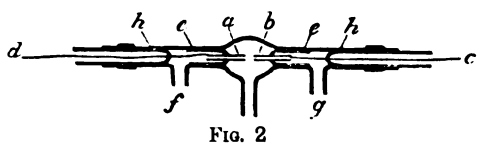

FIG. 2

to prevent the steam from passing the two. If they fit too tightly to allow this, air is apt to lodge between the metal and glass tubes, and if this gets driven out into the delivery tubes F G (Fig. 1) when the sparks pass, it will vitiate the experiment. The glass tubes *e e* stop short of the places *f g* where the delivery tubes join the discharge tube. The discharge tube is closed at the ends by two pieces of tube, *h h*, which have their ends inside the tube fused up; wires connected to the electrodes *c d* are fused through the closed ends of these tubes. It is desirable that the closed ends of the tubes *h h* should come up as close as possible to the exits *f g*, as air is very apt to remain in the tube if there are any places through which the steam does not rush. The tubes *h h* may either be fused on to the spark tube or fastened to it by rubber tubing. The delivery tubes F G (Fig. 1) are fused on to the discharge tube at *f g* (Fig. 2). These tubes are about 5cm. in diameter and terminate in narrow openings. It is essential that the steam and the mixed gases should escape through the tubes F G at approximately the same rate; to ensure this, the narrow extremities of these tubes should be equal both in length and width. This was attained by drawing out a piece of tubing which was originally of the same diameter as F G, and then cutting it at the middle of the narrow part; the two halves were then either fused or fastened by rubber tubing to F G. The narrow ends of F G are turned up and placed under mercury in the vessel M (Fig. 1). Over these ends, graduated eudiometer tubes are placed; these are filled with mercury at the beginning of the experiment, but the mercury soon gets displaced by the water produced by the condensation of the steam rushing through the tubes.

The heat produced by this condensation serves a useful purpose; it raises the temperature of the water in the eudiometer tubes over which the gases are collected to over 80° C., and thus, since hot water absorbs oxygen, but not hydrogen much less readily than cold, diminishes the disturbing effect due to the greater absorption of the oxygen than of the hydrogen by the water over which the gases are collected.

Precautions which it is necessary to take to ensure Correct Results.

To get rid of the air dissolved in the water I found no plan so efficacious as prolonged boiling. In the earlier experiments, in addition to the boiling, I tried to absorb the oxygen by mixing oxidising agents with the water; finally, however, I dispensed with these and trusted entirely to the boiling to remove the air. The distilled water was boiled vigorously for six or seven hours with the ends of the tubes F G open to the atmosphere. The eudiometer tubes filled with mercury were then placed over the ends of the delivery tubes F G, so that if any air were mixed with the steam it would be collected in these tubes. The steam was then allowed to run into the eudiometer tubes for about an hour, when the tubes were examined to see if they contained air. If any air was observed the eudiometer tubes were removed and vigorous boiling maintained until, on repeating the experiment, the air was found to have disappeared.

Method of Producing the Sparks.

The sparks were produced by means of a large induction coil, which would give sparks about 5cm. long when the current from five large storage cells, which was the usual battery power employed, was sent through it. The break used was, generally, the ordinary electromagnetic break supplied with these coils, but in some experiments a slow mercury break was employed. I found that, as I believe is the case with all induction coils, the condenser supplied with it had not nearly enough capacity to enable the coil to give out its maximum current. When I added to this condenser a large paraffin paper one, with a capacity of about 6 microfarads, the current from the coil was increased more than twenty times, and I found no difficulty in getting from 4 to 6 c.c. of hydrogen liberated per hour in the water voltameter in series with the discharge tube. In order to measure the quantity of electricity which passes through the spark tube, a well-insulated water voltameter was placed in series with it, and the quantity of hydrogen liberated in this voltameter observed. The gases liberated in this voltameter were repeatedly tested, in order to see whether there was any mixing up of the hydrogen and oxygen in the collecting tubes over its electrodes. Such admixture seemed possible, as the electromotive force produced when the circuit is "made" is in the opposite direction to that produced when it is broken. The test consisted in vigorously sparking through the gases collected in the voltameter, but no contraction occurred. As, however, it is very difficult to get a mixture of hydrogen and oxygen to explode if the hydrogen is greatly in excess, I added to the hydrogen in the voltameter enough oxygen to cause an explosion; the contraction in this case corresponded to the oxygen added, showing that there was no oxygen originally present. We may therefore conclude that the current sent through the secondary circuit on "making" the coil is in this case too small, in comparison with that produced on "breaking" the circuit, for its effects to be appreciable.

Method of Making the Experiments.

After it had been ascertained that all the air had been expelled from the vessel the eudiometer tubes were filled with mercury and placed over the ends of the delivery tubes, and the spark tube connected up with the coil. The next step was to see if the rates of flow through the delivery tubes were approximately equal. This was done by turning on the coil and collecting the mixed gases in the eudiometer tubes; if the volume of these gases in the two tubes was not the same, the apparatus had to be readjusted. When the rates of flow through the two tubes were the same the mixed gases were emptied out of the collecting tubes, which were refilled with mercury; the water voltameter was placed in series with the steam tube, and the coil again set in action. The steam which came up the collecting tubes condensed into hot water, which soon displaced the mercury; the mixed gases collected over this hot water, and were exploded at short intervals of time by sparks from a small Wimshurst machine. The gases did not disappear entirely when the sparks passed; a small fraction of the volume remained over after each explosion, and the volume which remained was greater in one tube than in the other.

The residual gas which had the largest volume was found on analysis to be hydrogen; the other was oxygen. Thus, by comparing the volumes of the residual gases in the two tubes it could

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readily be ascertained next to which electrodes the excesses of hydrogen and oxygen were appearing.

When a sufficient quantity of the residual gas had been collected, which generally happened when the sparks had been passing for an hour or an hour and a-half, a considerable volume of the mixed gases was allowed to accumulate, so as to make sure of an explosion when the spark from a Wimshurst passed through them. The coil was then stopped and the mixed gases exploded, and the quantity of hydrogen in the water voltameter determined. The residual gases in the collecting tubes were then analysed; the first step was to cool these gases, which while the steam had been rushing into the tubes had been at a temperature of more than 80°C., down to the temperature of the room. After this had been done the nature of these gases was determined by adding known volumes of oxygen and hydrogen, prepared electrolytically from water and observing the contraction which took place when a spark passed; the addition of the hydrogen or the oxygen, as the case might be, was continued until no further contraction took place on sparking.

The result of these analyses was that when the sparks were not too long the residual gas in one tube was found to be pure hydrogen, that in the other pure oxygen; if any other gases were present their volume was too small to be determined by my analysis. This result was only attained after considerable experience with the experiments and with the precautions necessary to obtain correct results; in the earlier experiments there was always a considerable quantity of some other gas (which, I suppose, was nitrogen) present.

When the sparks passing through the steam were very long I never succeeded in getting rid of this nitrogen; indeed, in some cases it amounted to more than 30 per cent. of the oxygen. I am not sure what the source of this nitrogen is; it may have been absorbed by the electrodes and given out when the sparks pass, or it may have come from the walls of the discharge tube, as these long sparks have a tendency to occasionally jump to the walls, and when they do so they may liberate air which would otherwise adhere to the glass.

Results.

The results obtained by the preceding method varied greatly in their character with the length of the spark; I shall therefore consider them under the heads "short sparks," "medium sparks," and "long sparks."

The lengths at which a spark changes from "short" to "medium" and then again to "long," depends on the intensity of the current passing through the steam, and therefore upon the size of the induction coil and the battery power used to drive it. The limits of "short," "medium," and "long sparks" given below must therefore be understood to have reference to the particular coil and current used in these experiments. With a larger coil and current these limits would expand; with a smaller one they would contract.

(To be continued.)

ARC LAMPS AND INCANDESCENT GAS BURNERS.*

BY DR. W. WEDDING.

Many recent researches have had for their object the investigation of the "incandescent gas lamp," which has of late years attained to such wide use, and the investigators have generally not confined themselves to this form of illuminant, but have also instituted comparisons with the electric arc. To two of these researches the author calls attention: that of Herr v. Oechelhäuser and that of Prof. Heim. The former compared incandescent gas lamps with both 16 and 50 candle incandescent electric lamps, in order to compare two

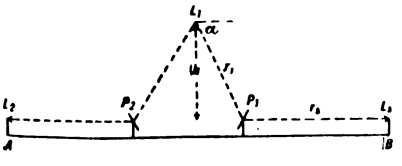

Fig. 1.

lamps of approximately equal candle power; but this can be better done by utilising the small arc lamps now made, which take currents of from one ampere upwards, and this method was adopted by Prof. Heim; but the author considers that these researches suffer from incompleteness. In a practical research it is no good measuring horizontal or any other illumination if the source of light be not provided with the usual shades or globes, since the latter entirely alter this distribution; and in detailing experiments on these practical points the author believes himself not to be traversing well-trodden ground.

* Abstract from *Elektrotechnische Zeitschrift*, No. 21, May 26, 1893.

The experiments were conducted as follows:—The illumination at various angles to the horizontal plane is measured as shown in Fig. 1, where L_1 is the lamp under investigation, A B the photometer bench, and L_2 and L_3 are lamps fixed at the height of

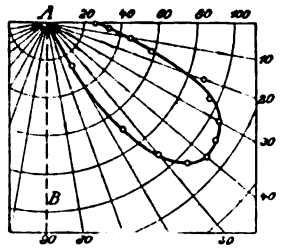

Fig. 2.

the two photometers P_1 and P_2. The two lamps are brought to the same brightness, and their strength determined with the amyl-acetate lamp, and L_1 is then started; when fairly burnt up,

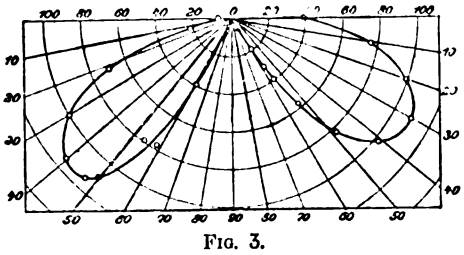

Fig. 3.

the height h over the axes of the photometers is so altered as to determine at every 10deg. inclination the candle-power, which is given by the formula $L_1 = L_2 r_1^2/r_2^2$ if the angles of incidence be

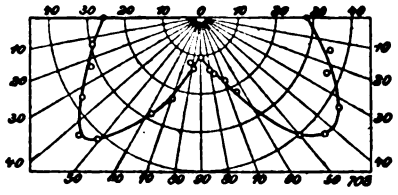

Fig. 4.

equal. The distribution above the horizontal plane is determined by cutting away the bench and sinking the lamp L_1; and, of course, every care is taken to burn the lamps in the best and most equable manner.

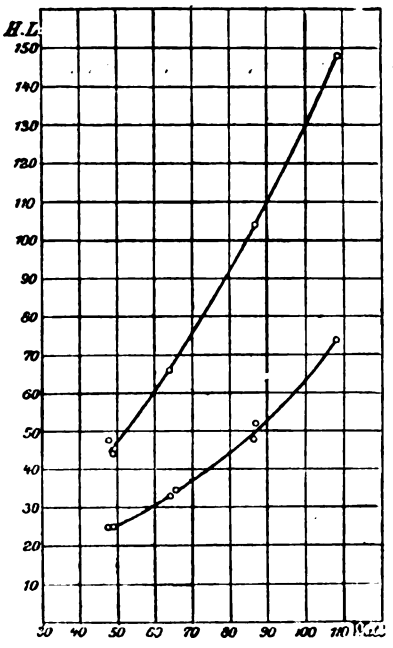

Fig. 5.

Two arc lamps were tried, one made by the Allgemeine Elektricitäts-Gesellschaft and the other by Siemens and Halske, with currents of 1·5-3 ampere. The former has a small opal globe

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made to sink with the burning away of the carbons, so that the arc always remains in its centre, and the whole lower part of the lamp is surrounded by another glass globe transparent and of pear-shape;

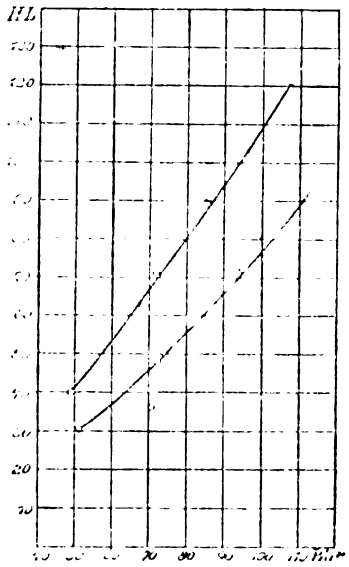

Fig. 6.

while the latter has only one glass globe of about the same dimensions as the transparent globe of the former; both have 500 ohm shunts. The first of these has the curve shown in Fig. 2, which

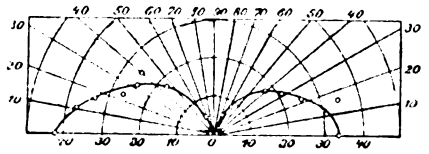

Fig. 7.

is the mean of the readings in two opposite directions for every angle. The actual observations are shown in Fig. 3. To obtain the mean spherical intensity, suppose the curve to rotate round a

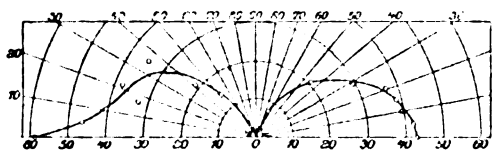

Fig. 8.

vertical axis A B, calculate the volume of the solid so described, arriving thus at the total light emitted below the horizontal; spread this on the surface of a hemisphere of radius 1, and we get

Fig. 9.

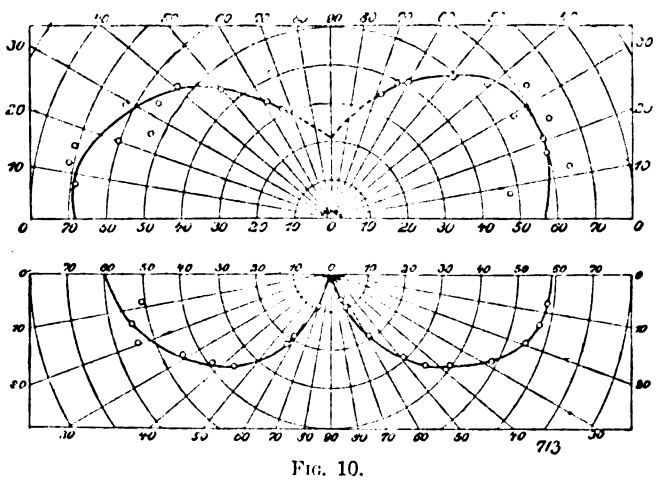

Fig. 10.

a number which we call the mean spherical intensity $i_m = V/F$, where V is the volume of the solid and F the surface on which the light is spread. Applying this to the above observations, we have $i_m = 66$ Hefner-light units, and as the watts spent are $= 64{\cdot}2$, we have for every watt a mean intensity of 1·03 Hefner unit.

These figures are *without shades*. With shades we have the curve shown in Fig. 4, the mean spherical intensity below the horizontal being 33 Hefner units, or 0·514 unit per watt. The next figure

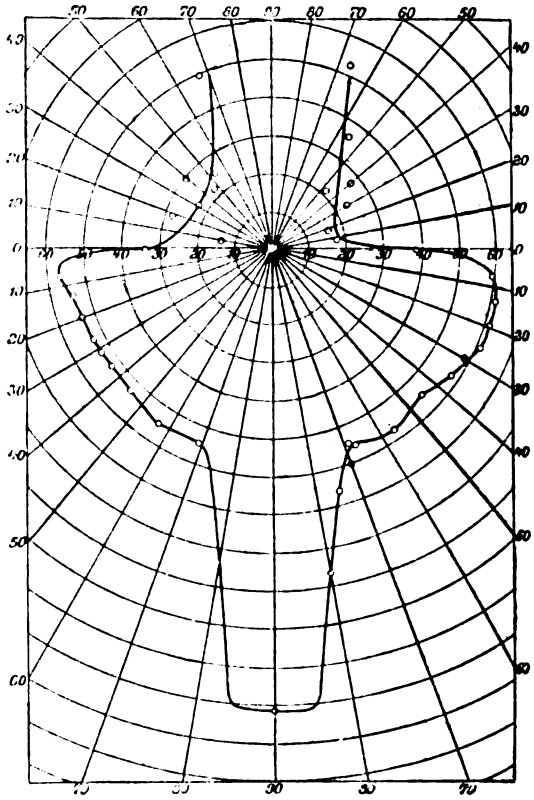

Fig. 11.

(Fig. 5) shows the mean spherical intensity for different values of watts, keeping the pressure constant and altering the current, the upper curve without shade, the lower one with; and the curve shows that for all values of the light the globe absorbs about 50 per cent. The same experiment with the Siemens and Halske lamp gives the results shown in Fig. 6, where it will be seen that the amount absorbed by the shade varies from 25 to 33 per cent., due to the fact that with larger currents a greater proportion of the light is sent upwards, as shown in Figs. 7 and 8, which give the upper distribution for 2·5 and 3 amperes respectively.

The gas glow-light was next investigated, a good burner, without globe, being supplied with gas at 35mm. (water) pressure, and the

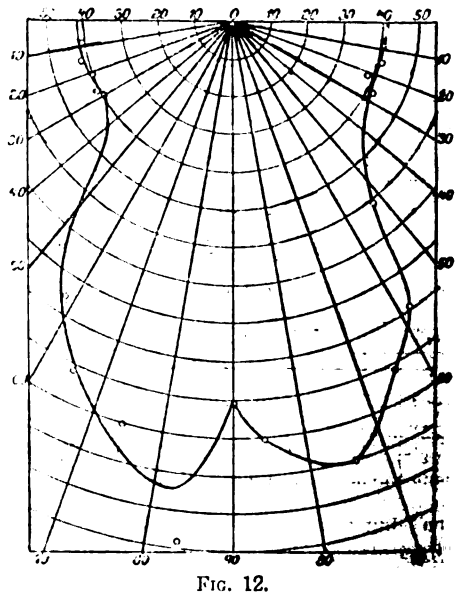

Fig. 12.

curves in a vertical plane are shown in the next two figures (9 and 10), which do not quite fit, having been taken on different days. The figures give a mean spherical intensity of 0·392 Hefner

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unit below and 0·503 above per litre of gas per hour* (1 litre = 0·035 cubic ft.), or 1·39 and 1·78 unit respectively per 100 cubic ft. It is thus seen that, owing to the distribution, an arc lamp with a shade and a gas glow lamp without one are equally exceptional. The irregularities in the curves are due to those in the incandescent material.

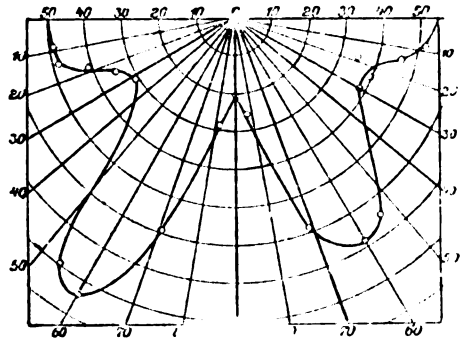

Fig. 13.

The shaded gas lamp was next tried, Fig. 11 referring to one with the usual white china reflector and white shade for the eyes, Fig. 12 to an opal globe. Figs. 13 and 14 relate to a bell shade and a matt globe respectively. The following considerations show that the figures obtained for the spherical intensity, namely,

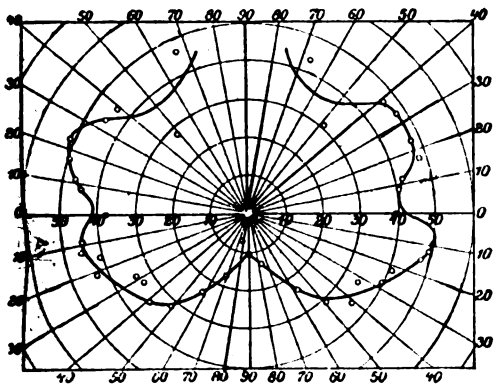

Fig. 14.

0·523 and 0·505 per litre per hour respectively (1·85 and 1·79 units per 100 cubic ft.) are not much use for purposes of comparison. A consumer knows nothing and cares less about mean spherical intensity, what he wants is that his show window or his table should be properly lighted, and he does not mind how this is effected. Consider Fig. 15. The intensity

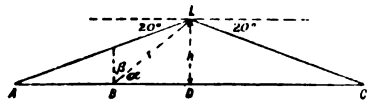

Fig. 15.

of illumination at any point B of the illuminated surface A C is $B = J \cos\beta / r^2$, where r is the distance from the source of light L, J the strength of the light coming in this direction, and β the angle of incidence; and this can be written also $B = J \sin^3 \alpha / h^2$, and from this equation with the help of the curves given the illumination at

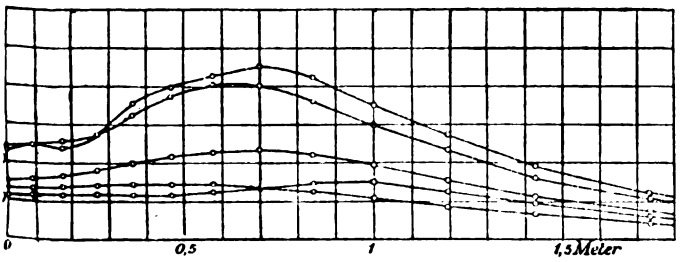

Fig. 16.—Distribution of Light from Siemens and Halske Arc.

every point on the surface can be calculated, as has been done in the curves Figs. 16, 17, 18 for the Siemens and Halske arc, that of the Allgemeine-Elektricitäts-Gesellschaft, and the incandescent gas-burner respectively, with their different shades. It is a very striking feature of these curves that the arc lamp far surpasses the gas burner in uniformity of illumination, a point which is of the utmost importance, since the eye chiefly notices differences of illumination, and not its absolute strength. The average strength is given as before, by the volume of the solid of revolution of the curve surface round the axis of ordinates, and is $i_m = V F$, which

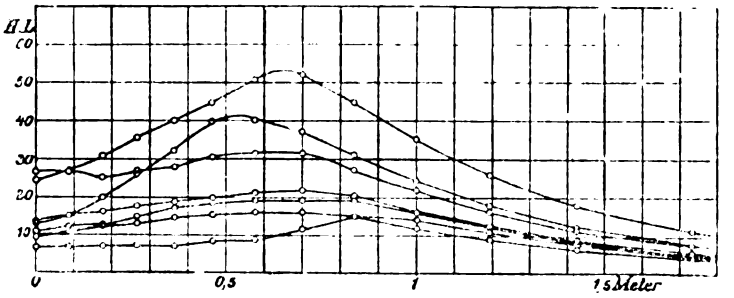

Fig. 17.—Distribution of Light from Allgemeine Gesellschaft.

works out naturally much more in favour of the arc light. To make the comparison of real value, an average of five burners was taken with the following results:—Take the case of a ground-glass globe for each. The gas lamp gives a mean spherical intensity of 0·0378 per litre of gas per hour, and the arc gives $i_m = 0\ 098$ per watt. Assuming that we can get by gas engine and dynamo 1,000 watts for one cubic metre of gas per hour it follows that we can compare the figures for one litre per hour and one watt; and we get, therefore, 2·6 times as much light by using the gas-driven arc lamp as by using a direct consumption of the gas in the Auer burner. In the worst case the arc lamp is better in the ratio

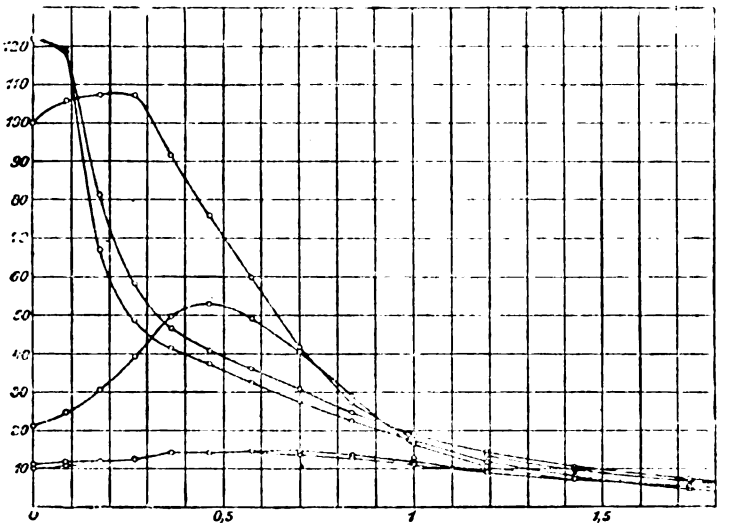

Fig. 18.—Distribution of Light from Incandescent Gas Burner.

1 : 1·3, and in the best it is 1 : 4. These figures apply only to new burners, and the five used were found to fall off 15 per cent. after 100 hours' use. The author leaves to his readers the evaluation of relative cost, which depends too much on local considerations to be of much value when worked out by general methods.

* The author uses throughout the word "litre," apparently meaning "litre per hour"; and the latter expression has been used throughout this abstract.

CORRESPONDENCE.

MEASUREMENT OF INTERNAL RESISTANCE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I quite agree with your Editorial remarks that for practical purposes it is unnecessary to measure the internal resistance of a battery or cell. What is wanted in most cases is to find the maximum current the cell will give for a considerable period of time without much falling off, and the terminal potential difference when giving this current. This can be done by using any form of ammeter or voltmeter, the battery being circuited through a known external resistance. When it is required to determine internal resistance, however, the real internal resist-

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ance is what is wanted and not its apparent value on the supposition that the electromotive force remains constant, as it is often desirable to know whether falling off in the current given by a cell proceeds from falling off of electromotive force due to polarisation, or increase of true internal resistance due to chemical change in the electrolyte. As a general rule the falling off in power of a cell when used is due to both these, and it is desirable to be able to separate the two effects.

With regard to the Holden cell tests, I did not suppose that this instrument would be used to accurately determine the resistance of a cell, but it seems rather absurd to give the internal resistance to two figures when there may be an error of about 10 per cent. due to inaccuracy *in reading alone*, while adding to this the effect due to polarisation the value obtained for the internal resistance may be 100 per cent. wrong or even more.

Take the reading for the E.C.C. cell as 1·36 instead of 1·38, the probable error is about 15 per cent. due to error in reading alone. I do not quite understand the meaning of your remark, " . . . a delay of a second or so will produce quite as large an error with most primary batteries, due to a change, not only in the readings, but in the quantity to be measured." Now the quantity to be measured is the internal resistance, and this will not appreciably change in a few seconds or even minutes; of course, as I have pointed out, the electromotive force changes in the course of even a fraction of a second. This prevents the value of the internal resistance as calculated being correct, but the real internal resistance remains constant during the time taken to make a test, hence the advisability of employing some method of eliminating the effects of polarisation.—Yours, &c., E. C. RIMINGTON.

THE CONDITIONS DETERMINING CHEMICAL CHANGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice that in your appreciative editorial comments on my note on the conditions determinative of chemical change, speaking of the influence of water, you say, "Its real function may only be to introduce an impurity, possibly an acid, into the sphere of action." Will you, therefore, allow me to point out that this scarcely conveys my meaning. It seems to me that *per se* the acid would have as little effect as water, as, *ex hypothesi*, neither is an electrolyte; but the two together form what I have proposed to term a "composite electrolyte," and an interaction might take place under their conjoint influence which neither alone could condition. In a sense, the water may be said to *introduce* the acid into the sphere of action; but the converse is equally true, and perhaps in many, if not in most, cases, the elements of the water molecule are alone subject to partition. Why a mixture of water and an acid is an electrolyte, and the precise character of the changes attending its electrolysis are *the* questions of the day—not answered by the fashionable ionic dissociation hypothesis, which appears to me to include a host of absurdities, and to be the outcome of extreme "narrow-mindedness."—Yours, &c.,

July 12, 1893. HENRY E. ARMSTRONG.

LEGAL INTELLIGENCE.

Blackie v. Electricity Supply Corporation (Limited).

This case came before Mr. Justice Cave and a special jury on Wednesday and Thursday. It was a claim for damages by Mr. W. G. Blackie, a watch and clock maker, of 379, Strand, on account of interference with his business caused by the working of the defendant Company's machinery in Maiden-lane. The Company denied that their works seriously interfered with the plaintiff's conduct of his business.

The counsel in the case were:—For the plaintiff, Mr. W. R. Bousfield, Q.C., M.P., and Mr. Morton Smith; and for the defendants, Mr. Fletcher Moulton, Q.C., Mr. English Harrison, and Mr. Terrell.

Mr. BLACKIE (the plaintiff) stated that his business of watch and clock maker had been seriously interfered with by the vibration caused to his premises by the defendant Company's electric light machinery. A standard clock in his shop by which he regulated the chronometers and clocks which he either manufactured or repaired had become absolutely of no use to him as he could not now depend upon it, and manufacturing work which he formerly did with the aid of this standard regulator he had now to put out to be done.

On Thursday the Plaintiff was cross-examined, after which THOMAS RUSSELL, his assistant, and others resident in the neighbourhood, gave testimony as to experiencing the vibration.

Mr. MILES WALKER (assistant to Prof. Silvanus Thompson) said that he went on June 8th to plaintiffs' premises. There was a very decided tremour perceptible on the roof, but it was not so strongly perceptible in other parts of the premises. On July 6th also he visited the premises, when the traffic in the Strand was stopped, and then again felt the vibration. He made tests of the number of beats per minute, and found there were 18. On the evening of July 10th he went to the engine room of the defendant's Company and found engines 2, 3, 4, and 5 running at 9 o'clock. He observed a vibration on the defendant's premises similar to that at the plaintiff's premises.

Cross-examined by Mr. MOULTON: He employed, to count the pulsations, an instrument which he constructed specially for the purpose, consisting of the spring from an Ayrton and Perry ammeter, to which was attached a glass fibre as a pointer; this enabled them to see what otherwise could only be felt.

Prof. SILVANUS THOMPSON visited the premises at about seven on the evening of June 1st last. At first the vibration was quite sensible, but ceased after a time, becoming sensible again later. He walked past the electric station and found a sensible vibration in the roadway outside. On June 8th part of the vibration was undoubtedly due to the Strand traffic. He visited the station and found five engines running, four doing work and one running light. On June 23rd he met Dr. Hopkinson at the plaintiff's premises; there was no vibration perceptible in the lower part of the premises, but on the roof the vibration was intermittent, part again being due to the Strand traffic. He went upon that date also to the station and found the total output at 3,200 amperes, which was about half the capacity of the station. So far as he could discover from somewhat incomplete data, engine No. 1, which was now away, had a greater disturbing influence than the others.

Cross-examined by Mr. MOULTON: Running four engines at half load would probably cause less vibration than two at full load. The fact that the vibrations tended at times to accelerate the running of the standard clock and at others to make it lose, might be accounted for by the assumption that the vibrations were of an irregular character.

Mr. FLETCHER MOULTON, Q.C., in opening the case for the defence, remarked that the amount of the output of the station was quite outside the control of the defendants, depending entirely upon the public demand, and it could not be said that there was any arrangement for special occasions, so that the vibration should be less; and when the jury visited the premises (which they did on Monday evening, July 10th) they saw what was the ordinary state of affairs. Mr. Miles Walker had never felt any vibration in the house, and Dr. Thompson only upon one occasion noticed a slight vibration. They had employed a most delicate instrument for the purpose of detecting the vibrations, and such a slight disturbance was not what could be described as a common law nuisance. There must be such a disturbance before the action could succeed, as would substantially interfere with the comfort of people generally in a house, and not with the carrying on of a particular trade. The variation spoken of in the standard clock was of a most minute character—one second in about 50,000. Plaintiff had never regularly used his clock until after the opening of the Company's station, and it was impossible to say what the cause of its irregularity was.

Dr. JOHN HOPKINSON deposed to having frequently visited the plaintiff's shop and being unable to detect any vibration not traceable to street traffic. He could not see that any conclusion could be drawn from a comparison of the register of the load at the central station and of the variations in the regulator clock. Chronometers which, though not precisely like regulators, had a considerable similarity, were used on shipboard, where there was a great deal of vibration, and were found to keep time perfectly.

Cross-examined by Mr. MORTON SMITH: The vibrations perceived upon the night of July 6th, when there was no traffic in the Strand, might have been due to traffic in other adjacent streets; he would not go so far as to say they were probably due to the defendants' machinery. The vibrations which he experienced were not of the regular character spoken of by the plaintiff's witnesses; they were so light that it was almost impossible to allocate them to any definite cause. The variations in the clock were such as might be due to wear and tear of the clock; he did not think they were in any way attributable to the working of the defendants' engines.

Mr. W. H. PATCHELL (the defendant Company's Electrical Engineer) said the engines at the station ran evenly. The same engines were running during the time of the jury's visit as were generally employed. The supply was entirely controlled by the demand of the public. The output in summer time was practically nearly as high as in the winter, but the maximum was not maintained for so long a time. He could trace no connection between the vagaries of the clock and the running of the engines at the station.

Cross-examined: The floors of the engine room were stiffened three months ago, and that lessened the possibility of vibration.

Mr. Edward A. Greening, architect and surveyor; Mr. Spencer Chadwick, Chairman of the defendant Company; the Rev. Fredk. Scrymgeour, Rector of Corpus Christi Church, Maiden-lane; Mr. Gustave Bargen, in the employ of the Tottenham Lager Beer Company, 395, Strand; Mr. Charles Fredk. Lawton, also of the Tottenham Lager Beer Company; and Mr. John Wm. Jones, sub-manager of the firm next door to the plaintiff, all gave evidence as to the absence of vibration.

The Court then adjourned.

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The Lighting of Exhibitions.

At Greenock Sheriff Court on Tuesday proof was heard in an action brought by the Gulcher (New) Electric Light and Power Company (Limited), against the promoters of the Royal Marine and Industrial Exhibition, recently held at Greenock, for £53. 12s. 10d. for supplying electric light to defenders' Exhibition. A counter action was raised by the promoters of the Exhibition against the Company for £50 for damages for failure to light sufficiently the football ground in connection with the Exhibition as per agreement and also for several smaller items. In the result a joint minute was lodged by which both actions were taken out of Court on the Exhibition promoters agreeing to pay the Company £32. 10s.

Elmore's French Patent Copper Depositing Company (Limited).

This matter came before Mr. Justice Vaughan Williams for the third time on Saturday last. Three petitions had been presented for the compulsory winding-up of the Company, but when last the case was before the Court application was made on behalf of the official liquidator for the postponement of any order until a contemplated scheme for the realisation of the assets in France had been carried into effect. The petitioning debenture-holders concurred in this application, but counsel appearing on behalf of the unsecured creditors objected. His Lordship suggested an arrangement between the parties, postponing consideration of the matter for the purpose; but on Saturday he made an order for the compulsory winding-up of the Company.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

Tenders Invited.—The Tramways Committee of the County Borough of Huddersfield invite tenders for the wiring of and for the supply of electric light fittings for the tramway offices, the plans and specifications for which may be obtained of Mr. A. B. Mountain, borough electrical engineer, Gasworks-street, Huddersfield, to whom sealed tenders must be sent not later than Tuesday, the 25th inst.

——— The Gas and Lighting Committee of the Bolton Corporation are prepared to receive tenders for the supply and erection of alternators and dynamos. Specifications and other information can be had of Mr. H. Rider, borough electrical engineer, and tenders must be sent in to Mr. Alderman Miles, at the Gas Offices, Bolton, by Thursday, August 3rd.

——— The Mayoralty of Jassy (Roumania) will on August 17th (old style) open tenders for the lighting of their town by gas or electricity. Particulars may be obtained from M. A. Solomonesco, Secretary to the Mayoralty, Administrative Office, Jassy.

——— The Carshalton Local Board invite tenders for lighting their district by gas, oil, or other illuminant for 12 months from the 31st inst. Tenders must be in by Wednesday next.

———Tenders are required by the municipality of Dusseldorf, for the supply and erection of a complete electric light and power plant. Tenders must be in by 11 a.m. on September 1st.

Tenders Accepted.—The tender of the International Electric Subway Company (Limited) has been accepted for the supply of the mains for the electric light installation at Portsmouth, for £13,539. Eight tenders were received.

——— The tender of Mr. E. Dewhurst, of Preston, has been accepted for the lighting of the G.U.O.O.F. Central Club at Burnley.

Appointments Vacant.—The City Engineer's Department of the Liverpool Corporation require an electrical engineer to act as electrical inspector. The salary commences at £150 per annum. Further particulars appear in our advertisement columns, and applications must be delivered at the office of the Town Clerk (Mr. George J. Atkinson) not later than 12 o'clock noon on Saturday, the 29th inst.

——— It will be seen by our advertisement columns that the Huddersfield Electric Lighting Committee are prepared to receive applications for the appointment of assistant electrical engineer. Applications are to be sent to Mr. H. Barber, town clerk, not later than Monday, the 24th inst.

Personal.—Mr. Claude W. Hill, manager for Messrs. Paterson and Cooper, asks us to state that his business address is now European Works, Pownall-road, Dalston, N.E., instead of Manchester.

——— Mr. John Lancaster has been appointed general manager of the electric tramways at Blackpool instead of Mr. J. Hesketh, who will require to give his whole time to superintend the new electric lighting system.

Removal Notice.—The offices of the Indestructible Ignition Tube Syndicate (Limited) are removed to more commodious premises at 100c, Queen Victoria-street, London, E.C.

The Holden-D'Arsonval Galvanometer.—With regard to the improvements in the Holden-D'Arsonval Galvanometer, described in our last issue, it should have been stated that these instruments are supplied, as well as made, by Mr. James Pitkin.

Messrs. Paterson and Cooper.—We have received from this firm a copy of their supplementary price list of electrical measuring instruments, together with a table of recent tests made with a view to determine the effect upon them of neighbouring conductors. In no position in which the voltmeter tested could be placed with respect to a lead carrying 1,700 amperes was the effect large enough to be of practical importance; while in the majority of positions, and at distances from the lead exceeding 4in. or 5in., the effect was quite inappreciable.

Gulcher (New) Electric Light and Power Company (Ltd.). We have received a copy of the new price list of the electric plant manufactured by this Company. The list includes dynamos, alternators, transformers, accumulators, motors, arc lamps and accessories, cables, measuring instruments, &c.

Taylor's Patent Flue Cover and Composition for Boilers and Furnaces.—We have received from Mr. G. C. Taylor, of Helsby, near Warrington, a description of his system of covering-in the tops of exterior flues in boiler furnaces. The method consists in the use of a patented compound, which can be readily applied and very quickly removed and replaced, and which possesses very low thermal conductivity. By means of this composition lining, it is possible to open out the roof of the flues and expose them to direct daylight, rendering the operations of inspecting, repairing, or cleaning much safer and more expeditious than in boilers provided with the usual brick lining. A large boiler can be opened, cleaned, re-covered, and the fires started again by two men working for $3\frac{1}{4}$ hours.

Messrs. Felten and Guilleaume.—We have received from this firm a catalogue of their exhibits at the Chicago Exhibition, which comprise electric light, telegraph, telephone, and torpedo cables; mining, marine, and other forms of metal rope, wires, and specimens of joints for cables.

National Telephone Company.—It has been decided to establish a Sports Club in connection with this Company's London staff, to be called the Telephone Athletic Association. An enthusiastic gathering recently took place, under the presidency of Mr. Dane Sinclair, the Company's chief engineer. A provisional executive committee was appointed, with Mr. T. C. Walker as treasurer and Mr. W. E. Dean as secretary.

Accrington.—At the last meeting of the Town Council a question was asked if the Local Government Board had replied to the application for permission to borrow money for the electric light scheme. The Town Clerk, in reply, said that the gas and water question had taken up so much of the time of the Legal and Parliamentary Committee that they had been compelled to postpone the consideration of the electric light question; the Local Government Board had given their sanction to the borrowing of the money for the scheme, but as they had grouped the land, machinery, &c., together, and only offered the Council 25 years for repayment, the Committee did not consider the conditions satisfactory.

Aberystwyth.—At the last meeting of the Town Council Dr. Harries proposed that, as the Council had done nothing under the Provisional Order which they obtained in 1891, the Public Lights Committee be authorised to negotiate with private or other companies, or with individuals, for the lighting of the town by the electric light, which was carried.

Bandon (Ireland).—A notice has been received by the Board of Guardians from the solicitor to the local Electric Light Company, stating that the Company intends to apply for a Provisional Order for the public and private lighting of the town by electricity, and the Board will call a meeting to consider the matter.

Birmingham.—The General Purposes Committee of the City Council have had for some time under consideration the question whether the Corporation should themselves obtain a Provisional Order for the supply of the electric light, and oppose the extension of the Order asked for by the Birmingham Electric Supply Company (Limited). It is understood that the Committee have decided that it would be inadvisable for the Corporation to undertake the supply of electricity, and they will therefore report to the Council in that sense. It would seem that the negotiations mentioned in the "Trade Notes" in *The Electrician* of June 23rd, page 215, as being carried on between the Company and the Corporation have resulted in a mutual understanding.

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BOGNOR.—The Local Board have been notified that the London and Lancashire Electric and General Engineering Company (Limited) intend applying to the Board of Trade for a Provisional Order, authorising them to supply electricity in the town.

BOLTON.—At the last meeting of the Corporation considerable discussion ensued with regard to the proposed electric lighting, Alderman Broughton taking exception to the decision arrived at by the Gas and Lighting Committee, and expressing his disagreement with the Engineer and the Committee in regard to the system approved of. He held that the continuous current should have been adopted, his idea being that although more costly, it was also safer than the alternating current. Councillor W. Cooper and Alderman Miles defended the Committee's decision, and in the result the Minutes of the Gas and Lighting Committee were confirmed.

CLERKENWELL.—The Works Committee of the Vestry have received a letter from Mr. H. F. Lewis, General Manager of the London Electric Supply Corporation, containing suggestions for the lighting of the parish by electricity. The current might, he says, be supplied either from the Company's Blackfriars sub-station or from a station in Clerkenwell itself. Arrangements could be made whereby the Vestry, after the installation was complete, might work it themselves. The Company were willing to surrender their rights under their Provisional Order for £1,200. The Committee did not, however, think it desirable for the Vestry to take any steps at present in the matter.

COLCHESTER.—Local authorities have evidently followed with interest the proceedings before the Joint Committee which has been considering the Electric Powers Protection Clauses. At the meeting of the Colchester Corporation last week the Roads and Drainage Committee reported that the Telegraph Department of the Post Office had applied for permission to erect poles in several of the streets for the purpose of carrying two telephone trunk wires, and recommended the Council to accede to the application. After some discussion the matter was referred back to the Committee in order that they might take the necessary steps to insure that these telephone wires should not be in positions where they might in the future interfere with electric lighting wires or wires in connection with electric tramways.

CORK.—At their last meeting the Corporation resolved to adopt overhead wires for the proposed electric tramway.

CROYDON. The Croydon Corporation on Monday resolved, subject to the sanction of the Local Government Board, to adopt the electric light for the centre of the borough at an estimated cost of £25,000.

DUNDEE. Messrs. Urquhart and Small, electrical engineers, reported to the Gas Commission at their monthly meeting on Thursday last that the work in connection with the lighting installation was now practically completed, and the whole of the work under the various contracts had been properly carried out. The installation had cost £19,607. 12s. 7d., including £599 for extras.

KENDAL.—Contracts for the whole of the work in connection with the proposed new Town Hall have been entered into, with the exception of the lighting. The Town Hall Committee are considering the advisability of lighting the building by electricity, but have not come to a decision.

KIEFF.—The British Consul for the district of Odessa, in his report, describes the electric tramway and the electric lighting arrangements of the town. The Company, which possesses the contract for street lighting, supplies the theatres, many of the principal shops, and private houses; but as the rates charged are rather high a large number of private consumers have their own plant, &c.

LEICESTER.—At a meeting on Monday of the members of the Leicester Co-operative Society it was decided by a large majority to light the premises by electricity, and the Committee were empowered to proceed at once with the work.

MAIDENHEAD.—Messrs. Pritchetts and Gold have notified the Town Council of their intention to apply for a Provisional Order authorising them, or a Company to be formed by them, to supply electricity in Maidenhead. At their last meeting the Council referred the matter to a committee for consideration.

NORTHAMPTON.—At the last meeting the Town Council decided to fit up the Old Reading Room for the electric light at an estimated cost of £30.

OXFORD.—The Oxford Electric Company took the opportunity of the Royal Wedding celebration to introduce a number of artistic and effective electrical devices in the general illuminations of the town, amongst which was included a trophy of flags with arc lamps suspended, accompanied on each side by photographic transparencies of the Duke and Duchess of York.

PERTH.—The newly-registered Caledonian Electric Supply Company (Limited) have informed the Town Council that they propose to apply to the Board of Trade for a Provisional Order authorising them to supply electricity within the Burgh of Perth, and asking the consent of the Corporation. Their letter has been referred to the Lord Provost's Committee for consideration.

POPLAR.—At Tuesday's meeting of the Board of Works the Works Committee recommended that now that Parliament had confirmed the Poplar Electric Lighting Order the clerk report at the next meeting on the subject, and the position of the Board on the matter. It was decided that the clerk should bring up an exhaustive report on the subject, with special reference to the experience of St. Pancras.

ROTHESAY.—The Rothesay Harbour Trust and Town Council at their last meeting notified the Caledonian Electricity Supply Company (Limited) that a proposed application by the Company for a Provisional Order for supplying the electric light to Rothesay would not be supported by the Council.

ST. ALBANS.—The City Council, at their last meeting, resolved that it was expedient that the city be lighted by electricity, and a Committee was appointed to consider and report on the steps to be taken for carrying out the work.

SEVENOAKS.—The Local Board have referred to the Lighting Committee a letter received from Mr. W. Hemmant, asking the support of the Board for an application to be made by him to Parliament for an Electric Lighting Order for the district.

TIVERTON.—At the meeting of the Town Council on Wednesday last the Town Clerk and the Borough Surveyor reported the result of an interview they had had with Sir Thomas Blomefield at the Board of Trade, when a promise was given that any application for an extension of time of the lighting Provisional Order obtained by the borough would not be opposed by the Board. The Town Clerk was authorised to make formal application for the extension.

TUAM.—The Board of Guardians have received a notification from the Tuam Electric Lighting Company (Limited) that they propose to apply to the Board of Trade for a Provisional Order enabling them to supply electricity within the Board's district.

TUNBRIDGE WELLS.—At the meeting of the Corporation on Wednesday last week the report of the Electric Lighting Committee was under consideration. The Committee recommended the Council to approve the plans prepared by Mr. Preece for the purpose of establishing a central station for the supply of the electric current for both public and private lighting, and to apply to the Local Government Board for sanction to borrow the sum of £13,000 for this purpose. After a lengthy discussion the recommendation of the Committee was adopted.

WORTHING.—At the last meeting of the Town Council the report of the Highways Committee, recommending the Town Council not to take immediate action in the matter of lighting the town by electricity, was approved.

PATENT RECORD

A record of Applications for Patents and Patent Specifications Published as compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

June 2, 1893.

10,788. The Hon. C. A. PARSONS. Birmingham. Improvements in the arrangement of stations for the generation of electricity.

10,821. W. S. BOULT, C. R. BOULT, and F. G. BAILY. London. Improvements in or relating to the regulation of electric currents.

10,830. E. BAILEY and G. M. GORDON. Improvements in electric storage batteries.

10,843. J. CLARET and O. WUILLENMIER. London. Improvements in or connected with electric railways and tramways.*

June 5, 1893

10,860. W. S. BOULT and C. R. BOULT. London. Improvements in or relating to arc lamps.

10,887. W. H. HILL HARTLAND. Sheffield. An improved system of town sewage disposal combined with production of electrical supply, and in means or apparatus therefor.

10,888. A. E. MUIRHEAD. Glasgow. Telephone receiver and transmitter.

10,937. A. H. HOWARD. London. Improved electric meter.

10,942. W. WALKER, jun., and F. R. WILKINS. London. Improvements in primary voltaic batteries.

10,963. E. A. CLARK. London. Electro-mechanical switch and system of electrical inter-communications.*

10,965. E. T. HUGHES. London. Improvements in insulating compounds. (Mathew A. Devey, United States.)

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1976. M. Guthrie. London. Improvements in apparatus for the electrolytical decomposition of brine and other liquids.

1987. F. R. Brown. London. Improvements in the electric propulsion of boats.

1993. G. Sciama. London. Improvements in electric search-light apparatus.

June 6, 1893.

2069. W. P. Thompson. Liverpool. Improvements in or relating to producing (or maintaining) continuous lines of telegraph wires, rails, pipes, and other metallic line structures, and in apparatus or devices connected therewith. (Elias Elkan Ries and Albert Henry Henderson, United States.)*

2077. C. Peterson. London. Automatic circuit breaker.*

2084. S. S. Allin. London. Improvements in arc electric lamps.

2092. M. L. M. Hellesen, *nee* Barnekow. London. Improvements in electric batteries.*

2099. H. H. Lake. London. Improvements in electric glow lamps. (Edward Allen Colby, United States.)*

2105. T. Craney. London. Improvements in electrolytic apparatus.*

2106. T. Craney. London. Improvements in electrolytic cells.*

2107. T. Craney. London. Improvements in electrolytic apparatus.*

2108. T. Craney. London. Improvements relating to the electrolysis of salts and to apparatus therefor.

2122. A. E. Peyrusson. London. Improvements in secondary batteries or accumulators. (Date applied for under Patents Act, 1883, Sec. 103, April 1, 1893, being date of application in France).

June 7, 1893.

2143. C. M. Dorman and R. A. Smith. Salford. Improvements in electrical switches, fuses, ceiling plates, wall connectors, and the like.

11,168. B. Death. London. Improvements in arc lamps.

11,176. J. T. Gent, A. W. Staveley, and J. H. Parsons. London. Improvements in electrical indicators.

11,177. P. Ward and E. Cooper. London. Improvements in fittings for electric glow lamps, and in the means of producing the same for decorative and advertising purposes.

11,184. Siemens Bros. and Co. (Limited). London. Improvements in apparatus for effecting electrical communication between a number of separate stations or apartments with a central station or apartment. (F. E. Morgan and H. E. Walter, United States).

June 8, 1893.

11,235. J. A. Wade. Liverpool. An improvement in electric motor fans.

11,294. R. Pippette. London. Improvements in automatic electrical exchange.

11,299. M. R. Van Leon. London. An improved electro-magnetic machine or motor.

June 9, 1893.

11,369. A. Gentzsch, J. Goldschmidt, and E. R. von Scanavi. London. An improved insulating compound and process of preparing same.*

11,304. J. S. Raworth. London. Improved method of, and apparatus for, regulating the electromotive force of electrical generators.

11,307. Sir C. S. Forbes, Bart. London. Improvements in microphones.

June 10, 1893.

11,331. R. Shepherd. London. Improvements in electric motors and dynamo electric machines.

11,426. H. L. Todd and G. Lewis. London. Electric motor.

11,427. J. C. Howell, R. E. B. Crompton, C. F. Clans (June), and the Crompton-Howell Electric Storage Company (Limited). Improvements in, and connected with, electric accumulators or secondary batteries.

11,439. G. Bryant. London. An improved machine for giving electric shocks automatically by the insertion of a coin.

11,446. W. E. Ulmer. London. An improved electric foot warmer.

June 12, 1893.

11,462. J. H. Holmes, F. Holmes, and J. B. Atherton. Liverpool. Improvements in or relating to electrical conductors.

11,464. W. P. Thompson. Liverpool. Improved galvanic electric belt or bandage. (Heinrich Theodor Biermanns, Germany.)*

11,516. J. T. Johnson. London. Improvements in alternate-current dynamos. (La Société l'Eclairage Electrique France.)

11,517. J. T. Johnson. London. Improvements in dynamo-electric machines. (La Société l'Eclairage Electrique, France.)

11,521. P. M. Justice. London. Improvements in electric motors. (The Clyde Electric Motor Co., United States.)

June 13, 1893.

11,557. W. J. Chivers. Sutton. Automatic electric call recorder.

11,567. P. Cadot and A. Charron. London. Electric lamp, gas, water, or motive force meter.

11,573. W. P. Thompson. Liverpool. A new or improved method of electrically welding metals. (Charles F. Coffin, United States.)*

11,579. W. P. Thompson. Liverpool. A new or improved method of and apparatus for electrically heating or welding metals. (Charles F. Coffin, United States.)*

11,596. W. Muir. London. Improvements in secondary or storage batteries

11,608. J. F. McElroy. London. Improvements in electrical heaters.*

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

10,451. Lucas and Others. Electric current transformers.

10,695. Shiels. Cover for electric push knobs &c.

10,735. Bull. Producing sodium potassium, &c., by electrolysis.

10,873. McEvoy. Electrical indicator apparatus.

10,876. Timmis. Reflecting and distributing electric light.

11,624. Lake (Noriega). Coin-operated telephone.

11,634. Wynne. Electric railways.

12,087. Schindler-Jenny. Electric heating devices.

12,122. McEvoy. Microphone mechanism.

12,311. Darragh and Gough. Electric alarms.

12,382. Sanders. Making wire, &c., by electro-deposition.

12,528. Anders and Kottgen. Telephonic apparatus, &c.

12,737. Jenner and Wilkes. Electrical switches.

1893.

4,923. New electric lamps.

5,771. Schaef. Electrical lighting.

6,556. Lake (Boyd's Medico Electrical Vitalizer Company). Medical electrical instruments.

6,922. Mitchell. Electrically heating crucibles, &c.

7,424. Waterhouse and others. Electric arc lamps.

7,471. Wilder. Electric annunciators.

8,320. Smith. Electric cigar lighter.

9,295. Craney. Electrolytic apparatus.

9,297. Craney. Electrolytic apparatus.

COMPANIES' MEETINGS AND REPORTS.

Eastern Telegraph Company (Limited).

The forty-second half-yearly ordinary general meeting of this Company was held yesterday at Winchester House, Old Broad-street, E.C., under the presidency of Sir John Pender, G.C.M.G., M.P.

The SECRETARY (Mr. George Draper) having read the notice calling the meeting and the minutes of the last meeting, which were confirmed, the report of the Directors was taken as read.

The CHAIRMAN then stated that the gross revenue for the half-year ended March 31st last had been £372,852, or a decrease of £9,355 compared with the gross revenue for the corresponding period in the previous year. Analysing the receipts from various sources, they found an increase of about £3,000 in the message receipts. There was a reduction in the traffic with several places, especially South America and Portugal, but this was more than recouped by the increase in other directions, notably South Africa, Egypt, Turkey, India, and beyond. The reduction in the gross revenue was due to their having received £17,700 from their investment in the shares of the Eastern and South African Telegraph Company as against £29,500 in the corresponding period of the previous year, or a decrease of £11,800. The Eastern and South African Company was practically an arm of their own Company, but for many reasons the two Companies were worked separately. The large bulk of the shares was held by their own Company. The total ordinary expenses for the half-year ended March last had been £102,499, compared with £105,820 in the corresponding period of 1892, showing a decrease of £3,321. The general expenses in London had been £9,369, or a decrease of £220, and the working expenses at stations had amounted to £79,926, being an increase of £1,231. Several of the items under this head showed substantial decreases, and the principal increase was in the salaries and wages of their staff at the stations, where there had been an increase of 30 clerks. They had also to take into account the operation of the scheme adopted some years ago to provide a regular scale of promotions for the younger men as they qualified themselves. Special repairs to buildings at stations had cost £1,974 less, and in connection with negotiations with foreign Governments there had been a decreased outlay of £1,375. Other telegraph companies hiring their ships had been charged a proportion of the depreciation for the period the ships were on the work of those companies. They had, therefore, for the half-year under review a charge of only £2,245 against revenue account for maintenance ships' fund, against £4,000 in the corresponding period of 1892. The expenses attending repairs and renewals of cables had been £32,533, being less by £20,882. They had received during the half-year over £26,000 for the hire of their ships for cable repairing purposes, and he thought they would regard this as very satisfactory. There was no position which the ships occupied so satisfactory to the Company as when they were doing nothing, but they had recently seen that while they were doing nothing for the Company they could find employment for them in working for other companies. They kept their fleet fully manned and in a thorough state of efficiency ready for repairs at short notice. After providing the usual amount for interest on Debentures Debenture stock, and Preference shares, they were able to propose the usual final dividend of 1½ per cent., and a bonus of 1½ per cent., making with the interim dividends already paid, a total distribution of 6¼ per cent. for the year ended March, 1893, and to carry the sum of £88,000 to the reserve fund against £66,000 a year previously. Last half-year, when he addressed them, he expressed his belief that he was submitting to them the best statement of accounts they had ever presented to the shareholders, but

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he thought they had materially improved their position in the past half-year. He only regretted that this improvement was more or less attributable to a great many of the disasters of which they had heard. Their cables were used for commercial purposes in good times, and when bad times came they were also employed in order that such times might be brought to an end as quickly as possible. When in previous years wars had occurred they had always endeavoured to help those who could not help themselves and had done what they could to ameliorate the conditions of the wounded soldiers and sailors. When the disaster to the "Victoria" occurred the other day, they found that there were many persons in this country who were extremely anxious to know who had been saved. He therefore at once communicated with Admiral Hoskins, informing him that whatever he or the Admiral at Malta thought ought to pass over the Company's lines free would be gladly accepted by them. As they were aware, the Company had been publicly thanked in the House of Lords by Earl Spencer. He was quite sure that the shareholders would thoroughly endorse the Directors' action in this matter. They had applied a further sum of £54,077 from reserve fund in reduction of the cost of the Aden-Bombay No. 3 cable and other capital expenditure, so that their capital expenditure, with the exception of some small additions to their land and buildings, remained at the same figure as last year. The total amount applied out of the reserve fund from time to time now reached the substantial sum of £1,256,822. They had thus practically duplicated and, in some cases, triplicated their system without increasing their capital. By keeping down their capital they secured in every way something like a permanent income. They could not stand still in such a company as theirs. An arrangement had been entered into with the Government for laying a cable to connect the Islands of Seychelles and Mauritius with Zanzibar and the Company's general system of cables and he believed that before the end of the year they would complete this important additional link to their very important chain of submarine cables. He might state that several other persons had applied for the Mauritius concession, but none of them were in the position occupied by this Company. They had had another battle. After practically obtaining a concession from the Portuguese Government to lay a cable connecting the islands of the Azores with Lisbon, some French people came in, and, backed by influence of their Government, they obtained the concession. The Portuguese Government, however, required a guarantee of £20,000, which was paid, but the French Government then backed out of supporting their people, who could not carry out the work. Their £20,000 was therefore forfeited, and the Eastern Company again stepped in and and succeeded finally in gaining the concession. He then expressed great regret at the loss which the Company had sustained by the death of Sir James Anderson—the late Managing Director—who had rendered the Company invaluable services for many years. His (the Chairman's) son—Mr. J. Denison Pender—had been appointed to the position, having been trained for the work for a long time. He was acquainted with very few men who knew more about the work than his son did, but he might state that the suggestion that Mr. Denison Pender should be appointed had not come from him so much as from other members of the Board. He concluded by moving the adoption of the report and the payment of the dividends and bonus recommended.

The VICE-CHAIRMAN (the Marquis of Tweeddale) seconded the motion. Some discussion followed, and in answer to questions,

The CHAIRMAN said that he received nothing for the time he expended on the business of the Company when he visited their stations beyond his regular remuneration as a Director, although he was the means of doing a good deal of work for the benefit of the Company on such occasions. The contract for the Azores cable was brought about, he believed, from the result of his visit to Portugal. Whenever he went beyond the sea-board he made no charge to the Company, and he paid for the expenses of any friends who accompanied him. He thought, under all the circumstances, that it would have been a graceful thing if the Company had offered to pay the expenses he incurred out of pocket on the occasion of these trips, which, in the interests of the Company, he wished he could take oftener. His time, however, was too valuable to allow him to do so. If they had not carried out their policy strictly of forming a large reserve fund, and of practically duplicating, and in many cases triplicating their system, without materially increasing their capital, they would not be in their present strong position. This policy had greatly increased the market value of their shares and stocks, but they could not have their cake and eat it too. If they were not paying an extra 1 per cent. in dividend they considerably strengthened the value of the share property. Whenever, however, they felt that they could prudently pay a higher dividend they would only be too happy to do so. The resolution was then unanimously adopted.

On the motion of Mr. BAYNES, seconded by Mr. JOHN NEWTON—both of whom expressed deep regret on behalf of the shareholders at the loss sustained by the Company in the death of Sir James Anderson—a vote of thanks was passed to the Chairman, Directors, and staff.

The CHAIRMAN acknowledged the vote, and the meeting then separated.

[*We shall publish a full report of this meeting in our next issue.*]

West African Telegraph Company.

The eighth ordinary general meeting of this Company was held yesterday at Winchester House, Old Broad-street, Sir John Pender, G.C.M.G., M.P., presiding.

The SECRETARY (Mr. John Cambrook) read the notice calling the meeting, and the minutes of the previous meeting, and the report of the Directors was taken as read.

The CHAIRMAN then said: Before asking you to approve the report I will, as usual, make a few remarks. Our gross revenue for the year 1892 amounted to £60,923 as against the takings for 1891 of £60,214, showing an increase of £709. The receipts from Portuguese stations show a large falling off, which, however, is balanced by a corresponding increase in guarantee received from Portugal. The receipts from French stations owing to military operations in Dahomey, show an increase. The Cape purse receipts also show an improvement, but owing to the falling off traffic with South America and British stations, and also to the fact we are making a comparison with a period when we carried a large amount of British traffic during the interruption of the African Direct Cable Lagos-Accra cable, the net increase in revenue, is as already mentioned £509. As stated in the report, we have again made a very heavy loss exchange, which affects our revenue by over £8,000. We are doing that is possible to minimise the loss in future transactions. The Portuguese Government have already sanctioned our collecting at a higher rate on certain classes of traffic, but they have not yet admitted the principle of allowing us to collect at the higher rate on the whole traffic. The bulk of the loss, however, is made in the remittances of the amount paid to us in Portugal by the Government on account of the guarantee. The total working expenses for 1892 amounted to £20,019 against £20,883, or a decrease of £864, the principal decrease being under the heading of general expenses in London £133; working expenses at Accra £427; foreign agency, £222; depreciation of cable stock, £82. Interest to cables amounted to £13,964, against £2,213 in 1891, or an increase of £11,751. As will be seen from the details given in Abstract C attached we have unfortunately had to effect an exceptional number of repairs. The work has been carried out by the Eastern and the Eastern and South African Companies' ships at actual cost, but notwithstanding this arrangement, the expense has been very considerable—so much so that the Directors consider it advisable to carry forward the whole balance of £2.410 without distributing anything in the way of dividend. As announced in the report, we have been obliged since the date of the accounts to incur further heavy expenses in connection with the diversion of the cable off the mouth of the Congo, but I trust when the work is carried out we shall be relieved from expenses of such an exceptional nature for some years to come. As a large proportion of our receipts derived from the joint-purse arrangement for the Cape traffic it is essential that we maintain our link in the alternate route to the Cape in a thorough state of efficiency. The expenses in connection with the diversion of our cable beyond the influence of the currents caused by the river Congo will involve a considerable burden on this Company for some time to come, but we are convinced that this course will be the most economical one, and in the end be in the best interests of the Company. The most rigid economy is practised in the management of the Company, and we look forward hopefully to better results in the future. These are the real facts of the case. A very important event has taken place since I last had the pleasure of addressing you, namely, the death of Sir James Anderson, who was from the inception of the Company, the Managing Director. We have lost in him a gentleman who took a very warm and lively interest in the Company, as he did in all the Companies with which he was connected. The fact of this Company practically completing our cable system round Africa was also, I think, looked forward to by us with a very great deal of satisfaction; it is with much regret, therefore, that I am obliged to say we are not in a position to pay a dividend. I look upon this circumstance, however, as temporary, and I think that when I address you at our next meeting we shall be able to present a better state of things. There are two circumstances which have been greatly against us, one of which is the heavy amount we lose by exchange. It is a very serious amount for a small Company like ours, and we are trying to persuade the Portuguese Government to enable us, not only by their own action in regard to the Government messages, but also with respect to the general messages, to recoup ourselves for the heavy loss we are now sustaining. The Government have refused to make any change in regard to their own messages, but I regard that as an unfair view to take, and not in accordance with a strict reading of the agreement with the Government. We shall not, however, fail to bring pressing on them to do us full and fair justice. The next important difficulty we have had to contend with, and which we have gone into most carefully, is in regard to the diversion of the cable mentioned in the Report off the river Congo. We have decided to divert that cable, which at the present moment crosses the mouth of the Congo. From our experience of this river and other rivers similarly situated we find that there are under-currents which we cannot understand, and their influence injurious. We have, therefore, decided to carry this cable about 140 miles out to sea, so as to be entirely free of the action of these under-currents. The removal will cost a good deal of money, but we hope it will enable us to give a certain service, and to secure the Company from interruptions and breaks. With these remarks I beg to move

"*That the report and accounts for the year ended December 31, 1892, submitted to this meeting be and they are hereby received and adopted.*"

Sir HENRY C. MANCE seconded the motion.

The CHAIRMAN, in answer to Dr. Kelly, stated that the interest on the Debentures, and the other claims of the debenture holders, had been met, both under the deed and as a matter of business, before the shareholders could receive any return. If the cables had not broken so many times this year, and thus cost them £13,000, the shareholders would have been given a dividend. He held £5,000 in the Debentures besides his shares; and his son had 1,000 shares. They would have been only too glad to have paid a dividend if they could have done so.

The resolution was then carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. J. DENISON PENDER, Sir Henry C. Mance was re-elected to his seat at the Board.

Mr. ALEXANDER HENDERSON afterwards moved, and Mr. CLIFFE OWEN seconded, the re-election of the auditors, Messrs. Price, Dever, Griffiths & Co.

The motion was carried unanimously, and the proceedings terminated.

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National Telephone Company (Limited).

The following is the report of the Directors for the year ended April 30, 1893, to be presented to the shareholders at the Thirteenth Ordinary General Meeting to be held at the Cannon-street Hotel on Tuesday next, the 18th inst., at 1 p.m. :—

The income accrued in respect of the business of the year amounts to £583,590. 2s. 11d., as compared with £463,741. 5s. 4d. for the preceding year, being an increase of £119,848. 17s. 7d. The rentals carried forward this year for unexpired terms of running contracts amount to £285,020. 7s. 8d., as compared with £234,370. 11s. 2d. for the preceding year, or an increase of £50,649. 16s. 6d. The working expenses and other charges (excluding debenture and other interest) amount to £311.644. 10s. 2d., as compared with £236.252. 0s. 5d. for the preceding year, being an increase of £75,392. 9s. 9d. The net result for the year, after deducting the Post Office royalties amounting to £54,220. 9s. 10d., is a profit balance of £217,725. 2s. 11d., as compared with a balance of £187.249. 19s. 3d. for the preceding year, being an increase of £30.475. 3s. 8d. Out of the available balance an interim dividend at the rate of 6 per cent. per annum on the First and Second Preference shares, and 5 per cent. per annum on the Third Preference and Ordinary shares has already been paid. The Board will recommend a further payment at the rate of 6 per cent. per annum on the First and Second Preference shares, and 5 per cent. per annum on the Third Preference and Ordinary shares, making the dividend for the year 6 per cent. on the First and Second Preference shares, 5 per cent. on the Third Preference shares, and 5 per cent. on the Ordinary shares The distribution on the Ordinary shares of 1 per cent. less than in the preceding year is recommended by the Board chiefly in view of the desirability of strengthening the position of the Company by carrying an adequate annual sum to the reserve fund. The Board propose under No. 113 of the Articles of Association to transfer to the reserve fund £30,000 (bringing that fund up to £134,627. 3s. 6d.), and to carry forward the balance of £2,194. 14s. 3d.

A reference to the capital account shows that during the year the purchase has been completed of the undertakings of the Western Counties and South Wales Company, the Sheffield Company, and several other minor companies. Though involving the outlay of £345,776, the Board believe that these purchases will be advantageous alike to the public and the shareholders, as enabling the telephone business of the country to be developed and conducted more efficiently and economically than it could possibly be if carried on in a disjointed fashion by a number of small and separate administrations. Since the end of the past financial year arrangements have been made for acquiring the Telephone Company of Ireland.

The Board have had to consider their position in relation to the New Telephone Company, which was launched in avowed competition with the National Company. The promoters of that enterprise soon began to appreciate the serious difficulties which lay before them, and, as the result of discussion, accepted the conclusion that if the shareholders were to be secured a reasonable return upon their capital it would be better, in the public interest, to work in harmony with the National Company, adopting as far as practicable the better features of the two systems. This resulted in an agreement, under which the National Company subscribed one-third of the capital of the New Company, and were represented on the Board of that Company. Subsequently it became apparent that the policy of the Government in assuming possession of the Trunk wires, forming the inter-town communication of the country, would greatly complicate the position of the licensed companies, and make unity of administration and interest essential to efficiency and success; therefore, upon the sudden death of the late Duke of Marlborough, who was the enthusiastic and moving spirit of the New Company, those who were associated with him recognised the necessity of still closer union with the National Company, and matters have ended in the National Company acquiring, partly by purchase and partly by the exchange of New Company's shares for National shares, nearly the entire interest in the New Company.

During the year negotiations of a difficult and complicated character in relation to the acquisition by the Government of the Company's trunk lines have been carried on with the authorities of the Post Office. The Board are gratified to be able to report that a draft agreement is now in course of preparation, which it is hoped may be shortly accepted and ratified by the contracting parties.

The rapid growth of the Company's business, and the expansion of its territory consequent upon the absorption of the several minor companies, coupled with the increasing responsibilities of the Board involved in the closer relations with the Post Office, pointed to the importance of bringing into the counsels of the Company some new members of a certain public position and experience. This necessity was unanimously recognised, and acting in the spirit that no question of personal interest should stand in the way of the interest of the shareholders, two vacancies were created by the voluntary retirement of Mr. John Bruce and Mr. Peter Garnett. The Board, under the powers conferred on them by the articles, were enabled to fill up these vacancies by the election of Lord Balfour of Burleigh, and of Sir Albert K. Rollit, M.P. The same spirit which actuated his two colleagues was displayed by Colonel R. Raynsford Jackson, who readily vacated his position as Vice-President of the Company in order that it might be filled by Lord Balfour of Burleigh, whom it was considered desirable to place in that important office.

At the general meeting four Directors retire, and being eligible offer themselves for re-election, viz., Lord Balfour of Burleigh, Mr. Charles Swain Agnew, Mr. George Hunter Robertson, and Sir Albert Kaye Rollit, M.P. Lord Balfour of Burleigh and Sir Albert Kaye Rollit, M.P., elected to retire, considering it would be respectful to the shareholders to submit their recent selection by the Board to the judgment of the proprietors. The auditors, Messrs. Welton, Jones, and Co., also retire, and are eligible for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

CALEDONIAN ELECTRIC SUPPLY COMPANY (LIMITED).—This Company has been registered in Edinburgh, with a capital of £100, divided into 100 shares of £1 each, to carry on the business of electrical engineers, electricians, suppliers of electricity, manufacturers of electrical apparatus, mechanical and chemical engineers, and to establish other businesses of a like nature. The following are the first subscribers (with one share each) :—Alex. F. Carmichael, electrical engineer, 7, St. Bernard's-row, Edinburgh; J. I. Hall, electrical engineer, 5, Shandon-crescent, Merchiston, Edinburgh; Henry R. Taylor, architect, 50, George-street, Edinburgh; W. K. Rose, advocate, 1, Drummond-place, Edinburgh; Alex. Ross Mackay, engineer, 10, Graham-street, Edinburgh; Peter Mackenzie, S.S.C., 3, Hope-street, Edinburgh; Alex. Slater, electrical engineer, Public Library, Edinburgh.

MISCELLANEOUS.—Northern Steel and Hardware Company (Ltd.). Capital £10,000, in £10 shares.——Walter Danks and Co. (Limited), iron merchants, &c. Capital £12,000, in £20 shares.

AUTOMATIC ELECTRICAL CORPORATION (LIMITED).—In reply to a notice from the Registration Department respecting the non-filing of the necessary returns, it is stated that the works have been closed and that the Company is in fact defunct. With a capital of £75,000, in £20 shares, the Company was registered in 1888 to act as undertakers for the supply of electricity, and in particular to acquire and turn to account an invention relating to an improved galvanic battery with apparatus for automatically supplying liquids thereto.

BAILY, GRUNDY, AND BARRETT (LIMITED).—The statutory return of this concern, made up to May 26, 1893, has been filed. Out of a nominal capital of £10,000 in £5 shares, 602 have been taken up, the full amount called, £2,950 paid, and £60 unpaid.

BARNET AND DISTRICT ELECTRIC SUPPLY COMPANY (LIMITED).—The usual return of this Company, made up to January 14, 1893, has been recently filed. The Company has a nominal capital of £5,000, divided into 490 Ordinary shares of £10 each, and 100 Founders' shares of £1 each. 80 of the former and the whole of the latter have been taken up, of which the latter were issued as fully paid. Upon 60 Ordinary shares, the full amount has been called, while upon the remainder £5 per share has been called, resulting in the payment of £700.

BROWETT, LINDLEY, AND COMPANY (LIMITED).—The annual return of this Company filed on June 17, 1893, shows that 200 Preference and 1,362 Ordinary shares, each of £10, have been taken up. 800 of the latter class have been considered as fully paid, while the full amount has been called, and £7,620 paid on the remaining shares.

CALLENDER'S BITUMEN TELEGRAPH AND WATERPROOF COMPANY (LIMITED).—The annual return of this Company, made up to May 23rd and recently filed, shows that 6,316 shares of £10 each out of a total of 8,000 have been taken up. 3,000 of these were issued as fully paid, while the full amount has been called and paid on the remaining 3,316 shares.

ELMORE'S WIRE MANUFACTURING COMPANY (LIMITED).—A petition has been presented by Messrs. Beckett and Co., bankers, of Leeds, for the winding up of this Company, and is down for hearing at the Royal Courts of Justice on the 21st inst.

CITY NOTES, &c.

BURTON-UPON-TRENT.—The Town Council of this Borough are inviting tenders for a Three per Cent. Loan, to be partly devoted to their electric lighting scheme. The minimum is £97 per cent., the total amount offered being £135,000. The stock is fully secured by borough rates.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended July 9th were £1,069, as against £733 for the corresponding period of last year, being an increase of £336. The total receipts for the half-year amount to £1,069, against £733 in the corresponding period of 1892, being an increase of £336.

COMPAGNIE BELGE DU TELEPHONE BELL.—At a recent meeting of shareholders it was decided to wind up this Company.

ST. JAMES' AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED). The Directors have declared an interim dividend for the half-year ended June 30, 1893, at the rate of 7 per cent. per annum on the Preference shares. The transfer books will be closed from July 14th to July 24th inclusive. The electric current sold by this Company during the quarter ended June 24th last amounted to £5,848, as against £6,643 in the corresponding period of 1892.

MADRAS ELECTRIC TRAMWAY COMPANY (LIMITED).—The *Madras Mail* of June 20th states that the Government of Madras has refused to grant the extension of six months applied for by the Company, in which to construct the tramway, on the ground that the condition necessary to the extension, that £75,000 capital should be subscribed, has not been complied with. The Company, therefore, loses its concession, and the deposit of 10,000 rupees is forfeited to the municipality.

TELEGRAMS TO BRAZIL.—The Eastern Telegraph Company (Limited) notifies that in accordance with instructions received from the Inter-

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national Bureau at Berne, telegrams for Brazil can only be accepted in plain language without figures or code words of any kind, and, further, that messages containing any allusion to Brazilian political affairs cannot be accepted.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended July 7, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,372.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Divi-dend.	Name.	Previous Week's Price. July 5.		Price Wednesday, July 12.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 12.	
								£ s. d.		Highest	Lowest
			TELEGRAPHS								
£1,134,640	Stock	12/6	Anglo-American	51	52	51	52	5 5 9	Jan., Apr., July, Oct.	51	..
£2,932,680	Stock	25/0	Do. Preferred	94½	95½	94	95	5 15 9	" " "	95⅝	94½
£2,932,680	Stock	5/0	Do. Deferred	10	10½	10	10½	..	.. .. ..	10½	..
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	99	102	99	102	3 18 5	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11⅜	12¼	11⅜	12¼	5 6 1	Mar., June, Oct., Dec.	12¼	11⅜
£36,400	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	106	110	106	110	4 10 11	June and December	..	..
£7,716,000	£100	7%	Commercial Cable Capital Stock	138	142	138	142	4 18 7	April and October	..	..
16,000	10	8/0	Cuba Submarine	11½	12½	11½	12½	6 8 0	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	18½	19½	18½	19½	5 2 7	" "	19½	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½	3½	2½	3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅞	12⅛	11⅞	12⅛	5 15 8	Jan., Apr., July, Oct.	12 1/16	12
400,000	10	2/6	Eastern	15½	15½	15½	15½	4 3 10	" "	15½	15⅛
70,000	10	6%	Do. 6 per Cent. Preference	16½	17	16½	17	3 10 7	" "	..	..
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112	115	112	115	3 9 7	May and November	114½	113½
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	108	111	108	111	4 10 1	February & August	..	..
250,000	10	6 6	Eastern Extension	15⅞	16	15⅞	16	4 7 6	Jan., Apr., July, Oct.	15 1/16	15⅞
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	113	116	113	116	3 9 0	February & August	..	..
£70 600	100	5%	Do. 5 p. c.(Austln. Gov. Sub.) Debs 1900	102	105	102	105	4 15 3	January and July	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb.,1900	101	104	101	104	4 16 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	102	105	102	105	3 16 2	February & August	..	..
£200,000	£25	..	Do. 4% Mauritius Sub. Debs. .....premium	3½	4	3½	4	..	May and November	..	..
180,227	10	2/3	Globe Telegraph and Trust	9⅞	10	9⅞	10	4 10 0	Jan., Apr., July, Oct.	10	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	15⅝	15⅞	15⅝	15⅞	3 15 7	" " "	15⅞	15⅝
150,000	10	5 0	Great Northern	19½	20	19½	20	4 5 0	Jan., April, and July	20	19⅝
£100,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105	108	105	108	4 12 7	March & September	..	..
17,000	25	37/6	Iado-European	39	42	39	42	5 19 1	May and November	..	..
37,548	10	4/0	London Platino-Brazilian	4	6	4	6	6 13 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent Debentures	107	110	107	110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs.	99	102	100	103	3 17 8	" "	..	..
11,802	8	4/0	Reuter's	5	6	5	6	..	April and October	..	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6 per Cent.	120	125	120	125	4 16 0	" "	123	..
15,609	10	5/0	West African Telegraph	5½	6½	5½	6½	7 13 10	January and July	..	..
£260,900	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	3	4	3	4	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	99	103	99	103	7 15 4	June and December	..	..
88,321	10	6d.	West India and Panama	1⅛	1⅜	1⅛	1⅜	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½	11	10½	11	5 9 1	May and November	10 1/16	10⅝
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9½	10½	9½	10½	5 14 3	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	105	108	105	108	4 12 7	June and December	107½	..
64,242	15	4/6	Western and Brazilian	7¼	7⅜	7¼	7⅜	4 13 11	May and November	7⅜	7⅛
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	6	6½	6	6½	5 15 3	" "	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1½	2	1½	2	..	..	1 1/16	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 10 1	February & August	..	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106	109	106	109	5 10 1	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120	125	120	125	5 12 0	May and November	..	..
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	100	103	100	103	5 16 6	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	2	3	2	3	..	..	..	..
22,500	1s/0	3½d.	Consolidated Telephone Const. & Maintenance	⅛	¼	⅛	¼	..	May and November	—	..
200,000	£1	4½d.	Oriental (11s. paid)	⅛	¼	⅛	¼	..	Yearly	..	..
458 867	5	2/6	National	4⅝	5	4⅝	4⅞	7 18 2	June and December	5 1/16	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref	14⅜	15½	14⅜	15½	6 3 1	" "	15⅝	15
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14½	14⅝	14½	14⅝	3 18 8	" "	14⅝	..
90,950	5	6⅜d.	Do. 5% Non-Cumulative 3rd Pref (£3 paid)	5⅜	5⅝	5⅜	5⅝	4 1 4	" "	5 9/16	5⅜
726 477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	110	115	110	115	..	..	..	..
58,000	5	1/0	United River Plate	2½	3	2½	3	3 18 3	January and July	113⅜	111½
£146.370	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	11½	11¾	10½	10⅝	..	..	11 3/16	..
20,000	10	..	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½	13	12¾	13¼	..	..	13 1/16	12½
19,900	£5	..	Electricity Supply Co. for Spain	..	..	..	..	..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	..	..	5	5¼	..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	..	..	..
8,322	£5	..	House to House Electric	..	..	1½	2½	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..	..	5⅜	5⅝	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	6	6½	..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4 1/16	4 1/8	4 1/16	4 1/8	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6⅜	6⅝	6⅜	6⅝	..	..	..	..
111.000	5	..	London Electric Supply	..	¾	..	1	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6	6½	6½	7	2 17 2	..	6⅞	6⅜
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102	105	102	105	4 15 3	June and December	..	..
6,452	£10	..	Notting Hill Electric	5	6	5	6	..	..	..	..
9,980	£5	9½%	St. James' and Pall Mall	7½	7¾	7½	7¾	..	..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	7⅞	8¼	7⅞	8¼	4 4 10	..	..	..
59,900	5	2/0	Westminster Electric Supply (fully paid)	5¼	5⅜	5¼	5⅜	3 0 10	..	5 1/16	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/6	Brush Electrical Engineering	3	3½	3	3½	..	..	3½	3
75,000	2	6%	Do. 6 per Cent. Preference	2⅛	2⅜	2⅛	2⅜	5 1 1	..	2 3/16	2⅛
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107	109	107	109	4 2 7	March & September	108	107
20,000	5	3/6	Crompton and Co., 7 per Cent. Cumulative Pref.	5¼	5⅜	5¼	5⅜	6 1 9	January and July	..	..
12,139	5	..	Edison and Swan United	..	..	..	..	..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..	..	1⅞	2¼	..	..	..	..
49,900	10	12/0	Electric Construction	1½	2	1⅞	2¼	..	..	2	..
91,195	2	10/0	Elmore's Patent Copper Depositing	¼	⅜	⅜	⅝	..	..	⅜	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1	2	1	2	..	..	..	..
50,000	10	15/0	India Rubber, Gutta Percha &c., Works	23	24	23	24	5 4 1	February & August	23½	23⅛
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	2½	3½	2½	3½	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	..	..	..	..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	5/0	6/0	5/0	6/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	1¾	2¼	1¾	2¼	15 19 0	May and November	2⅛	2
37,350	12	24/0	Telegraph Construction and Maintenance	34	36	33	35	5 2 10	March and July	34½	34⅛
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	..	..	..	..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	..	..	..	..	—	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	6%	City and South London Railway	36	38	35	37	1 13 9	May and November	..	..
37,500	£10	£10	Liverpool Overhead Railway	4½	4¾	4½	4¾	—	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 792.—Vol. XXXI. FRIDAY, JULY 21, 1893. PRICE FOURPENCE. *Annual Subscription (U.K.), 19/6*

NOTES.

A comparison between the results which we publish this week of the tests that have been recently made by Prof. Kennedy, upon the latest pattern of a Parsons steam turbine, and the results of former tests, will show a most satisfactory improvement in this engine in most, if not all, directions. Our readers will remember that in Vol. XXX., p. 25, we commented on the report of the tests made by Prof. Ewing *last* August. We were then able to give a very favourable comparison between the results of those tests and the previous performances of a Parsons engine. This generator which, in 1888, consumed a very large amount of saturated steam per horse-power hour, was found by Prof. Ewing to have reduced its full-load consumption to 27·6lb. per E.H.P. hour or 37lb. per Board of Trade unit; one of the principal sources of improvement being the use of superheated in place of saturated steam. The normal output of this plant was 100 kilowatts, the speed being as high as 4,800 revolutions per minute. The plant recently tested by Prof. Kennedy was "in external dimensions almost exactly the same as that tested by Prof. Ewing"; the speed, 4,500 revolutions per minute, was somewhat lower, and the pressure and amount of superheating at full-load were substantially the same. Yet the maximum output which it was possible continuously to maintain from the plant was greater in the ratio of about 150 : 100, and the consumption per unit of energy was considerably reduced. The steam consumed per E.H.P. hour was found to be only 20·3lb. at full load, as against 27·6lb.; or, per Board of Trade unit, 27·2lb., as compared with 37lb. in the former trial, showing an improvement of nearly 24 per cent. Thus in the several points of output, speed, and efficiency, the engine seems to have been overhauled, altered, and substantially improved. There is also a commensurate improvement of the efficiencies at reduced loads.

Prof. Perry supplies us this week with a short article which illustrates numerically and graphically the effects which take place when an alternating-current circuit is made up of a choking coil and condenser placed in series. His curves are similar to those of Messrs. Bedell and Crehore, given in *The Electrician*, Vol. XXX., p. 6, and which have since been incorporated in their work on alternating currents. The present article, however, unlike that of the American authors, clearly explains the method of calculating the curves, and contains numerical data, which enables any one interested to form a more correct idea of the nature of the changes which occur. The three curves given by Messrs. Bedell and Crehore appear practically identical, so sharp is the peak to which they rise. In reality, however, these curves differ considerably from one another. The excessive rise of current which all these curves show when the inductance of the circuit attains its critical value, is due to a condition of things which can hardly be easily realised with actual coils and condensers.

The investigations of Dr. Lewis Jones on the duration of the discharge of an induction coil, which we print this week, present several points of interest. He has used a very sensitive chemical recording device, far more delicate than that of Bain; and a tracing made by the current from the mains of the Metropolitan Electric Supply Company shows that there is no dragging out of the record, either by continuation of the chemical action or by accumulation of colouring matter under the style. No spark-gap was used, and the resistance of about 1,000 ohms, offered by the damp paper on which the record was made, approximates to that of the human body. The conditions of the experiment, therefore, much more nearly resemble those of the ordinary medical application of an induction coil than those of the researches of Blaserna and of Colley, to which Dr. Jones refers. Whether a further examination would reveal oscillations in the tailing-off of the "break" discharges or not is of small importance from a medical point of view. The result shows that the discharge approximates much more to an ordinary alternating current than to an abruptly intermittent current, and encourages the hope that medical men will be able before long to measure these minute currents, and to express their doses in some intelligible measure.

In an article on the electromagnet, published in this issue, Dr. Frölich appears surprised that no attempt has yet been made to unite the theories of Dr. Hopkinson and Mr. Kapp. For our part, however, we have so long regarded these two theories of the magnetic circuit as essentially the same that no attempt to reconcile them seems necessary. Dr. Hopkinson's mode of expressing the law was more orthodox than that used used by Mr. Kapp, but the latter was much more easily grasped. Mr. Kapp introduced the simple and most useful notion of magnetic resistance, and although the other theory also involved this idea, it was not so clearly

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expressed. On the other hand, Mr. KAPP somewhat marred the value of the Paper in which he first stated his theory by introducing an empirical formula for the law connecting magnetising current and induced magnetism, which unfortunately did not at all well coincide with experimental results. Dr. FRÖLICH has been prominently connected with the various attempts which have been made to get an empirical formula for the law of saturation; but although a great deal of skill has been spent on these efforts, we do not think the results obtained are a sufficient compensation for the labour. Dr. HOPKINSON made no attempt in this direction, simply referring to the experimental curve connecting magnetising force with magnetism, and this method is the one universally adopted in design.

WITH reference to M. D'ARSONVAL'S ingenious use of a mercury thermometer to measure alternating magnetic fields, which was described on p. 378 of our last issue, it has been pointed out to us that much the same idea was mentioned by Mr. MORDEY in the course of the discussion on Mr. SWINBURNE'S Paper on "Transformer Distribution," read before the Institution of Electrical Engineers in February, 1891. Mr. MORDEY pointed out that a very good magnetic leakage detector for transformers consisted of a spirit thermometer and a mercury thermometer side by side; the leakage lines setting up eddy currents in the mercury and not in the spirit, and heating it and not the other thermometer. We may add that for weak alternating fields, in which the eddies set up in the mercury are not sufficiently powerful to render negligible the ordinary variations of temperature, M. D'ARSONVAL uses a petroleum or an air thermometer, in the bulb of which he places a little copper tube.

WE cannot, as a rule, find space in our columns for recording fatal accidents with electric light on the other side of the Atlantic, one reason being that the conditions of work differ so greatly from those in this country, that no useful lesson can be learned from them. The reprehensible practice of switching current on to mains while there is a possibility of workmen being in contact with the wires is, we hear, once more responsible for the death of a lineman. The accident occurred at Ottawa, the lineman not having finished the junction of the line with a building when the current was switched on. The remedy for this risk is the strict observance of the pre-arranged time at which the mains are to be re-connected to the supply. Rubber gloves are only fit for use by thoroughly experienced engineers who know the untrustworthy nature of the protection which they offer.

IT is a curious irony of fate that the London Electric Supply Corporation, which, as we remarked a week or so ago, reckoned upon complete immunity from actions for nuisance in connection with its electric lighting operations, should have been perhaps the worse bitten of any; at any rate, publicly, for there is, of course, such a thing as settling a claim privately out of Court. The case of "Blackie *v.* Electricity Supply Corporation," following immediately upon that of Dart *versus* the same Company, must afford no little relief to those responsible for the running of generating machinery planted in the heart of densely-crowded districts. Juries are notoriously "down on" railway companies, and the existence of high-pressure boilers and high-speed machinery in the closest proximity to shops, hotels, and dwelling-houses, might very possibly have set the "heavy damages" chord of the juryman's heart into vigorous vibration, and have rendered him oblivious to all considerations of justice and equity. The result of two actions referred to, however, show that this is not the case, and it is something to be thankful for.

A RECENT issue of the *Electrical Engineer* of New York contains a Paper and a short note on "Calculating Armatures." The title puzzled us at first, as our thoughts were carried to phenomenal "calculating boys"; but we find that this is not an announcement of a new prodigy, but merely a new method for getting out armature quantities. The method "is based on the analogy between the torque at the periphery of the armature and the pressure on the piston of a steam engine." If occult analogies can ever evolve good armature proportions, this one may do as well as another. In a similar manner we might design a flap-valve from its analogy with a five-barred gate, or an arc lamp from its analogy with the rush-light.

The Heilmann Locomotive.—The trials of this electric locomotive have been commenced at Havre.

The Waterloo and City Railway.—The Unopposed Bill Committee in the House of Lords passed the Waterloo and City Railway Bill last week.

Cable Interruptions and Repairs.—

	Interrupted.	Repaired.
St. Thome—Loanda	May 30th.	July 18th.
Paramaribo—Cayenne	April 15th.	—

Eastbourne.—On Sunday last many of the streets of Eastbourne were flooded to the depth of several feet. The circuits of the local electric lighting Company were not, however, interfered with in any way.

University College, Bristol.—The 1893-94 Session of this college begins on October 5th. Information as to the Electrical Engineering and Chemistry courses will be found in our advertisement columns.

Aluminium Reduction.—The Pittsburg Reduction Company has, it is said, contracted with the Niagara Falls Power Company for 6,500 E.H.P., for use in a new aluminium plant to be erected at Niagara Falls.

Appointment Vacant.—The Committee of the Manchester Municipal Technical School invite applications for the post of Assistant Lecturer in the Physical Department. For further particulars see our advertisement columns.

Patents in Canada.—Of 3,417 patents granted last year in Canada, 2,227 were taken out by American citizens, 671 by Canadians, 298 by Englishmen, 106 by Germans, 26 by Frenchmen, and 89 by persons of other nationalities. The receipts amounted to about £17,000, and the profits £9,000.

The American Institute of Electrical Engineers at the Chicago Exhibition.—The Exhibition headquarters of the American Institute of Electrical Engineers are, says the *Electrical Engineer* of New York, being rapidly put into habitable condition. The rooms are at the south end of the Electricity Building, and will be fitted up handsomely and comfortably for the reception of members.

Platinum.—The available information as to the Russian platinum industry has been increased by a visit made by Mr. George F. Kunz to the district, and described by him in the recently published eleventh census report of the mineral industries of the United States. The average daily yield of the

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whole of the Government district is about 9lb., worth about £2 per ounce, and the yearly production is about 1,620lb.

An Electrical Horse-whip.—A recent number of *Electricité* describes a horse-whip which is constructed so as to give a slight electric shock to the animal upon which it is administered. The handle, which is made of celluloid, contains a small induction coil and battery, the circuit being closed by means of a spring push. The extremity of the whip consists of two small copper plates, insulated from one another, each of which is provided with a tiny point. The plates are connected to the induction coil by means of a couple of fine inuslated wires. Electric shocks of considerable severity have, we believe, been used for some time by horse trainers; but the apparatus described in *Electricité* appears to be unlikely to injure or inflict unnecessary pain on the horse.

Long-Distance Telephony and Railway Passenger Traffic.—An American electrical contemporary suggests that the cause of all the recent experimenting and the willingness of the American Railway Companies to put on faster trains between Chicago and New York is not entirely due to competition among themselves, nor any special demand by the public, but to the great strides made in the telephone business, the use of the telephone for the last three or four years having somewhat cut off business traffic on the railways. It is possible, our contemporary points out, for a Board of Directors, part of whom live in Philadelphia and a part in New York, to hold its meeting by telephone, and the law courts have decided that such meetings are legal.

Electric Lighting in Europe.—Mr. Wm. McDevitt, electrical expert of the Philadelphia Fire Underwriters' Association and the Philadelphia Fire Patrol, recently paid a visit to Europe to examine, from the underwriters' standpoint, into the methods of wiring employed here, and he has just made a report. The general impression left on Mr. McDevitt's mind after looking at our underground work is "that an enormous amount of money has been spent in the hope that some day it may pay. From the complaints of the electric companies it is very evident that, so far, they are very much handicapped by this immense outlay." With regard to electric fire experiences in Europe and America, Mr. McDevitt arrived at the—to him—satisfactory conclusion that the nations of the two continents were "all pretty much on a level."

Copper v. Silver.—With a view to maintaining in some measure the price of silver, economists are now on the look out for a new commercial use for this much depeciated monetary metal. We are afraid that silver, cheap as it is, is not yet cheap enough for extensive use in the electrical industry. Silver is at present half-a-crown an ounce, and is expected to reach two shillings; copper is about £45 a ton, or ½d. per ounce troy. To compete with copper as a conductor, therefore, silver at two shillings an ounce would have to exhibit some marked improvement upon the electrical properties of copper, which, unfortunately, it does not do; in fact, from the electrical point of view silver and copper are practically the same metal, their conductivity, temperature coefficient, and tensile strength being very much the same.

The City and South London Railway.—In the House of Commons on Monday Mr. Byles asked the Chancellor of the Exchequer if he was aware that the City and South London Railway Company charged fares exceeding a penny per mile for the distance actually travelled by the passenger; that on these fares exceeding a penny per mile no passenger duty had been paid; on what grounds this privilege had been permitted to the City and South London Railway; and on what terms other railways might obtain a participation in this privilege. Sir J. Hibbert said that the facts were not as stated in the question. The Company was liable for duty on the fares received at the rate of over a penny per mile. But owing to the peculiar method adopted for the payment of fares it was difficult to determine the extent to which the Company was liable. An arrangement had been arrived at between the Commissioners of Inland Revenue and the Company, under which the Commissioners were satisfied that the liability was fully discharged.

Mr. Edison's "Albert Medal."—A curious exhibit of Mr. Edison at the Chicago Exhibiton are some samples of the many medals, awards, diplomas, and other decorations which he has been accumulating during the past ten years. Amongst these is the Albert Medal, recently awarded him by the Society of Arts in recognition of his electrical inventions. With this medal is shown the correspondence connected with it. First of all there is a letter from the Prince of Wales, then there is a letter from the English Ambassador, who refers to the "inestimable benefits" which Mr. Edison has conferred "on all nations"; the correspondence prosaically concluding with a letter from a United States Secretary of State to whom the medal was entrusted, informing Mr. Edison that he can have the medal on paying the postage.

The Glasgow Telephone Exchange.—Advantage was taken of the recent Fair Holidays to get the new telephone arrangements in Glasgow made available for the subscribers. For the double metallic connection between the exchange and the subscribers a length of at least 1,000 miles of wire additional had to be run. It is all of silicium bronze, and of 16 B.W.G. In the new switch room and testing-room at the Royal Exchange at least 500,000 soldered joints or connections had to be made, and some 50,000 spring jacks had to be fixed in position, about 5,000 of them in the testing-room. There are about 3,200 subscribers in connection with the Glasgow Telephone Exchange, but the ultimate capacity of the switch-room will be something like 10,000 connections.

Testing for Arsenic.—In cases of medical jurisprudence it is, says *Industries and Iron*, unfortunately often necessary to test for arsenic. It was, and we fear still is, usual to use zinc to produce arseniureted hydrogen. There is great difficulty in procuring zinc absolutely pure and free from arsenic, and as the least trace of arsenic in the zinc might result in untrue evidence being given, which might cost the life of a human being, it seems strange that such a test should ever be used now. It is obvious that zinc should not be employed. A small battery with platinum electrodes will produce the arseniureted hydrogen, if there is any arsenic present, without risk of any misleading results due to impurities. This method was proposed some time ago, but we believe the dangerous method with zinc is not yet superseded, owing to the conservative dread of anything new—especially anything electrical.

The Marking of Foreign Meat by Electricity.—On Wednesday last Lord Onslow's committee, appointed by the House of Lords to consider the practicability of marking foreign meat, held their last sitting for the purpose of taking evidence. At previous sittings it had been suggested that the meat should be marked by electricity, but a doubt arose whether the electrical marking would hasten decomposition, and it was accordingly arranged that two legs of mutton should be experimented upon. On Wednesday Mr. Joseph Kincaid, of the firm of Kincaid, Waller, and Manville, produced a machine which his firm had invented for the purpose of electrically marking meat, and also two legs of mutton (one of which had been marked) which had been in the possession of an independent butcher for a sufficient length of time to test the rate of decomposition. Mr. Kincaid said that though practically there was no difference between the two legs, the electrically marked one was perhaps slightly the better of the two.

Bradford.—On Wednesday last a special meeting of the Gas and Electricity Supply Committee of the Town Council was held for the purpose of conferring with Lord Kelvin, who visited Bradford for the purpose, on the best mode of extending the electricity supply works. Lord Kelvin's written report, which had already been placed before the Committee, stated that he had had a full discussion of the whole subject in conference with Mr. Baynes and Mr. Shoolbred and that after careful consideration of the whole subject, he was of opinion that the best arrangement for improving and augmenting the electricity supply was to adopt the three-wire system recommended by Mr. Baynes. "The method proposed by Mr. Shoolbred," says Lord Kelvin, "whether for a three-wire system or a five-wire system, according to which the adjustments of the pressure for the consumers at different parts of the system are entrusted to automatic mechanism at the feeder ends, is not adapted to give in ordinary circumstances the requisite uniformity of pressure to the consumers, and is liable

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also to serious dangers and objections." When the time comes for still wider extensions Lord Kelvin thinks a second generating station would be better than adopting the five-wire system. The conference on Wednesday was very protracted, and extended over a period of about three hours.

Telegraphy in Persia.—The mode in which telegraph lines in Persia under native control are erected and worked is described by the British Consul at Resht in reference to the line between Enzelli, on the Caspian, and Resht, and Teheran. In dry weather, he says, the line works fairly well, but in damp or rainy weather it cannot be counted upon. The reason is that the insulators are driven into trees that have branches growing round the hooks and touching the wires; but when a large tree is not available a small one is used, and this often breaks, or the shaking of the slender tree by the wind dislodges the insulator or hook on which it is fixed, and the wire trails on the ground. The Consul has often seen the wire right across the high road, which is followed by hundreds of mules both in Ghilan and Astrabad, not only interrupting telegraphic communication, but endangering the lives of the animals and their riders, more especially when the accident happens on the brink of a precipice. It is not surprising, under these conditions, that telegrams in Persia are not received punctually. In one case a high foreign official telegraphed to Teheran from Europe announcing his intended arrival at Resht in a fortnight. The telegram was received at Teheran the same day by the European line and immediately despatched to Resht by the Persian line. The fortnight elapsed and the high official arrived. The telegram was received in the sender's presence 18 days after its despatch.

Electrical Engineering at the Merchant Venturers' School. The governors of this institution have decided to improve the equipment of the electrical engineering department. For this purpose a complete installation will be provided. It includes two small dynamos of different types, built by the students of the school, and a large 4-pole experimental dynamo, specially built by the Brush Company. The latter has its field-magnet coils so wound that it can be used as a series, shunt, or compound-wound machine; it is also provided with a special exploring coil in the armature, so that magnetisation of the armature can be examined, and the machine is so constructed that an alternating current of slow periodicity can be obtained. These three dynamos will be driven by a horizontal gas engine, and will be used not only for experimental purposes, but also for charging a set of storage batteries placed in the electrical laboratory; from these cells currents will be conveyed to the lecture theatre and to the laboratory tables. During the past few weeks the senior students in the electrical engineering section of the school have been busily engaged in placing the necessary cables and wires throughout the building, and the whole will be in readiness for use during the ensuing winter session. Considerable additions are also being made to the electrical measuring instruments of the school, and it is proposed to utilise the town electrical supply for experiments with alternating currents, as well as for lighting a part of the building. The remainder of the school premises will probably be gradually wired by the students.

Thunderstorms.—On the 5th inst. the ss. "Ludgate Hill" was struck by lightning in mid-Atlantic during a severe storm. The lightning struck the foretopmast and split it in two. The second officer was knocked off the bridge, and a fireman was hurled a distance of 20ft. along the deck.—Further particulars are now to hand relative to the fatalities caused by the storms of last week. At Long Stratton three men and some horses sheltering under a tree were struck by lightning, and one man was killed. Tree-like impressions were discovered on the unfortunate man's body, but his clothes were quite uninjured. In the Midlands two fatalities occurred. In Ireland a man unknown was found dead on the public road some seven miles outside Kilkenny. There was a punctured wound on the left side of the head. The body was much burned, and some trees adjacent to where the remains were found were burned by lightning. In the Knocks district, near Bandon, two men, fearing the iron tools in a forge "would attract the electric fluid," went into the dwelling-house attached. They had scarcely entered the house when a discharge struck the thatched roof which was instantly ignited, and killed them. The forge escaped uninjured. At Burton-on-Trent the lightning struck a house, and not only fetched out the palisading from the front of the house and laid it in the middle of the road, but also knocked down the chimney. The lightning seems then to have passed over two adjoining houses and struck the third house, where it fetched the spout down.

The Sayers Feeder Compensators at Derby.—The following particulars of one of the new compensators for fall of pressure in feeders, constructed by Messrs. Mavor and Coulson, on the lines suggested by Mr. W. B. Sayers in his recent Paper read before the Institution of Electrical Engineers, may be of interest:—The feeder is to be used in connection with the three-wire electric lighting system of the Midland Railway Station at Derby, for which Mr. J. Sayers is responsible. The compensator will be placed in the engine-room, the current to the feeder which it controls passing through it, by which means the pressure is automatically raised by an amount just sufficient to compensate for the drop in the feeder, whatever the current flowing may be. In this way the necessity for hand regulation and pilot wires is dispensed with. The compensator proper consists of a pair of low-pressure series dynamos mounted on the same shaft, and driven direct by a constant-speed motor. The current to the extreme positive feeder traverses one of the armatures, and that to the extreme negative feeder traverses the other. In order to compensate for the drop of pressure in the third wire when a current is flowing in it, the balancing current is taken round the keepers in such a manner as to compensate for the disturbance which is caused by the drop when such a current flows owing to the unequal loading of the two sides of the system. Two sets of compensators have been constructed for the Derby Railway Station, one to carry a maximum current of 500 amperes, and to raise the pressure 1 volt for every 95 amperes; the other to carry a current of 400 amperes, and to raise the pressure 1 volt for every 55 amperes.

The Chappe Telegraph.—Thursday last week was fixed for the unveiling of a statue of Claude Chappe, the inventor of what was once known as the "French Telegraph"; the necessary funds having been subscribed by the French telegraph staff, and a site having been given by the Paris Municipality. The Chappe telegraph rendered considerable service, and created a good deal of excitement during the Napoleonic wars, and was, it is unnecessary to say, not an electric but a semaphore telegraph. In a little volume entitled "Histoire de la Télégraphie," published in 1824, M. Chappe l'Aîné gives the history of the subject from the earliest times, and urges the general use of semaphore telegraphy by the commercial world. Claude Chappe brought his system of telegraphy to the notice of the Assembly on Thursday evening, March 22, 1792, but it was not until April 4, 1793, that permission was granted to carry out experiments, the outcome of which was an order to erect a line from Paris to Lille, which was at work by the end of 1794. In 1798 the line was extended to Dunkerque, and in 1803 to Brussels, lines being run to Strasburg and to Brest in 1798, and to Milan in 1805. The Chappe apparatus consisted of a long narrow arm which could be revolved into any desired position, with two smaller arms at either end of it also capable of taking up different positions relative to the main arm; at night time five lamps mounted on gimbals rendered the positions of the arms visible. By means of this apparatus 196 different signals could be made. To connect Paris with Boulogne at the time Napoleon was meditating an invasion of England, huge two-arm semaphores, very similar to our present railway signals, were employed, powerful lamps with parabolic reflectors being used at night. The arms were 18ft. long by 2½ft. broad. The author makes merry over the English Admiralty telegraphs, which it must be admitted were very crude apparatus compared with that of Claude Chappe. The semaphore line from London to Portsmouth, which sent its last message on December 31, 1847, was, however, capable of a certain degree of celerity; under favourable circumstances, with all the operators ready, the Greenwich time ball signal could be sent along it and answered in ¾min.

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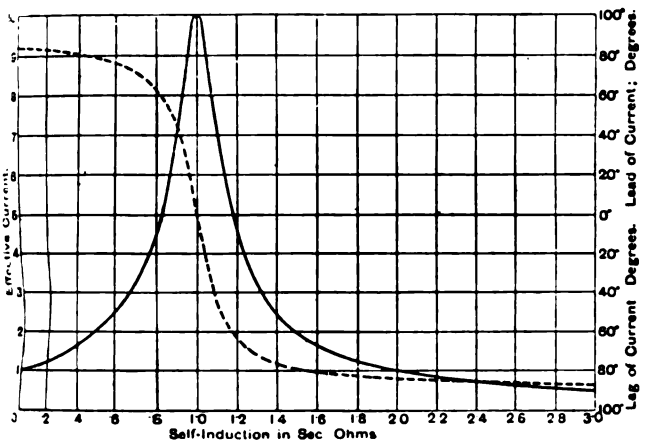
COIL AND CONDENSER IN SERIES.

BY PROF. PERRY, F.R.S. (AND H. BAYLY).

Instead of studying algebraic expressions, my students are in the habit of making numerical experiments. Many of their results are interesting, and although they cannot be looked upon by mathematicians as new, they are, I believe, new to the average student. The following is one of many examples which may be given. I neglect hysteresis in iron and eddy currents because the results are of the same character as if these phenomena were also considered. To take them into account it is only necessary to complicate the mathematical work in the manner indicated in my Paper on Choking Coils (Physical Society, March 11, 1892). A coil of resistance R and self-induction L is in series with a condenser of capacity K. If V



is the potential difference between the ends of this arrangement, whose resistance may be said to be $R + L\theta + \frac{1}{k\theta}$, the current C is

$$C = \frac{V}{R + L\theta + \frac{1}{K\theta}} \text{ or } \frac{K\theta V}{1 + RK\theta + LK\theta^2}$$

using θ to mean $\frac{d}{dt}$.

If V follows the law $V_0 \sin pt$ it is obvious (*see* the easy rule, Royal Society *Proceedings*, Vol. LI., p. 457, 1892) that the amplitude of the current is

$$\frac{K p V_0}{\sqrt{(1 - KLp^2)^2 + K^2 p^2 R^2}},$$

and the *lead* of the current is $\frac{\pi}{2} - \tan^{-1} \frac{RKp}{1 - LKp^2}$.

To study this, let R = 100 ohms, K = 1 microfarad, or $K = 10^{-6}$; let the *effective* voltage (or $V_0 \div \sqrt{2}$) be 1,000 volts; then for the following values of L we have the following effective currents and leads calculated by Mr. Bayly :—

L, in secohms.	Effective current, in amperes.	Lead of current, in degrees.	L, in secohms.	Effective current, in amperes.	Lead of current, in degrees.
0	0·995	84·28	1·05	8·944	- 26·57
0·1	1·110	83·67	1·1	7·071	- 45·0
0·2	1·240	82·87	1·2	4·472	- 63·43
0·3	1·414	81·87	1·3	3·162	- 71·57
0·4	1·644	80·53	1·4	2·425	- 75·97
0·5	1·961	78·67	1·5	1·961	- 78·67
0·6	2·425	75·97	1·6	1·644	- 80·53
0·7	3·162	71·57	1·7	1·414	- 81·87
0·8	4·472	63·43	1·8	1·240	- 82·87
0·9	7·071	45·0	1·9	1·110	- 83·67
0·95	8·944	26·57	2·0	0·995	- 84·28
0·975	9·701	14·03	2·5	0·665	- 86·18
1·00	10·00	0	3·0	0·499	- 87·13
1·025	9·701	- 14·03			

These results have been plotted by Mr. Bayly. It is interesting to see how the current increases slowly at first, as self-induction is introduced, and then more rapidly, reaching a maximum when L = 1 secohm, and diminishing again exactly in the way in which it rose, and becoming less and less slowly as L is very great. The change of *lead* into *lag* is also very interesting.

The current is a maximum when $LKp^2 = 1$, and it is then the same as if we had no condenser and no self-induction—as if we had a mere non-inductive resistance R. It is interesting to note that this condition $LKp^2 = 1$ is the relation which would hold between L, K and p (neglecting the small resistance term) if the condenser K were sending surging currents through the circuit R, L, connecting its two coatings.

THE THEORY OF THE ELECTROMAGNET.*

BY DR. O. FRÖLICH.

The Theorem of Hopkinson and the Magnetic Circuit.—It is somewhat surprising that, even in recent works on electromagnetism, no attempt is made to unite the theories of Hopkinson and Kapp, or to connect Hopkinson's theorem with the supposition of a magnetic circuit. We give this connection in the following.

Hopkinson, as well as Kapp, put the ampere-turns of the electromagnet equal to a sum of terms, each of which terms corresponds to a part of the electromagnet. If we denote the ampere-turns by MJ, the number of the lines of magnetic force in the air-gap by K, the length of a part of the electromagnet by L, the section by Q, Hopkinson's function by f, the coefficient of leakage by c, and if the indices 1, 2, &c., correspond to the different parts of the electromagnet (no index to the air-gap), Hopkinson's theorem is the following :—

$$\frac{4\pi}{10} MJ = L\frac{K}{Q} + L_1 f\left(\frac{c_1 K}{Q_1}\right) + L_2 f\left(\frac{c_2 K}{Q_2}\right) + \ldots ;$$

and if we denote by ϕ the function of saturation introduced by Kapp, by w the specific magnetic resistance of the air, by $\sigma_m = \frac{c_m K}{K'_m}$ the saturation, K'_m being the maximum of lines of force attainable by the part m, Kapp's equation will be

$$\frac{4\pi}{10} MJ = \frac{4\pi}{10} w L \frac{K}{Q} + L_1 \frac{c_1 K}{Q_1} \phi(\sigma_1) + L_2 \frac{c_2 K}{Q_2} \phi(\sigma_2) + \ldots$$

Each term in one equation must be equal to the corresponding term in the other equation; consequently, we have

$$f\left(\frac{cK}{Q}\right) = \frac{cK}{Q}\phi(\sigma) = \frac{cK}{Q}\phi\left(\frac{cK}{K'}\right),$$

and for the air, $\frac{4\pi}{10} w = 1$.

Hence it is clear that Hopkinson's theorem harmonises with the supposition of a magnetic circuit, and can be deduced from it, and that the theorems of Hopkinson and Kapp are identical.

Hopkinson's function is equal to the magnetic tension of the unit of length in a piece of iron; his theorem tells us that in a closed magnetic circuit the magnetomotive force is equal to the sum of the magnetic tensions at the ends of the different pieces.

Kapp's theorem corresponds to Ohm's law, if there is no leakage, and to Kirchhoff's second law, $\Sigma E = \Sigma JW$, if there is leakage; while Kirchhoff's first law, $\Sigma J = \sigma$, when applied to magnetic circuits, is a matter of course.

Kapp's function is in a simple way connected to Hopkinson's function; but the form

$$\frac{\text{tang}\frac{\pi}{2}\sigma}{\frac{\pi}{2}\sigma}$$

given by Kapp, does not agree with the observations.

Formulæ for the Functions of Hopkinson and Kapp.—Kennelly stated that the magnetic resistance, $\frac{mi}{k}$, of iron is a linear function of the ampere-turns, mi, except in the

* Abstract from the *Elektrotechnische Zeitschrift*, 1893, No. 25ff.

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beginning of the curve. If we turn this observation into a formula representing the whole curve, we obtain

$$\frac{ni}{k} = a + \beta n i - \frac{\gamma}{\delta + ni}$$

where $n = \frac{4\pi}{10} m$; k being the number of the lines of force in a piece of iron of the unit of length and of the unit of section.

This formula can be employed in finding forms for Hopkinson's and Kapp's functions. First we observe that $\frac{1}{\beta} = k'$, the maximum of lines of force and ni depends only of the form, $\frac{1}{k} - \frac{1}{k'}$. Therefore, we introduce, as affecting the argument, the *rate of saturation*,

$$\lambda = \frac{k}{k' - k} = \frac{1}{\frac{k'}{k} - 1}$$

By this change we obtain more simplicity and natural meaning in the formulæ; in wrought iron, for instance, the ampere-turns are almost exactly proportional to the rate of saturation. We derive the following formulæ; for Hopkinson's function:—

$$ni = \frac{1}{2}(ak'\lambda - \delta) + \frac{1}{2}(ak'\lambda + \delta)\sqrt{1 - 4\frac{\gamma k'\lambda}{(ak'\lambda + \delta)^2}},$$

or

$$ni = ak'\lambda \left\{ 1 - \frac{\gamma}{a^2 k'} \frac{1}{\lambda + \frac{\delta}{ak'}} - \frac{\gamma^2}{a^4 k'^2} \frac{\lambda}{\left(\lambda + \frac{\delta}{ak'}\right)^3} - \ldots \right\}$$

and for Kapp's function:

$$\frac{ni}{k} = a(1+\lambda) \left\{ 1 - \frac{\gamma}{a^2 k'} \frac{1}{\lambda + \frac{\delta}{ak'}} - \frac{\gamma^2}{a^4 k'^2} \frac{\lambda}{\left(\lambda + \frac{\delta}{ak'}\right)^3} - \ldots \right\}$$

These formulæ agree with the middle curves observed by Hopkinson for wrought and cast iron, partly with sufficient, partly with high exactitude, and from the beginning to the end.

If we ask only for sufficient exactitude between the ordinary limits of saturation, omitting very low and very high saturations, the following most simple formula can be used:

$$\frac{ni}{k} = \rho^0 + \rho' \lambda = \rho^0 + \rho' \frac{k}{k' - k}.$$

Formula for the Electromagnet.—Taking the last formula representing the magnetic resistance of iron, we obtain for the electromagnet:

$$\frac{NJ}{K} = A_0 + A_1 \frac{K}{K_1 - K} + A_2 \frac{K}{K_2 - K} + \ldots \ldots$$

where $\frac{NJ}{K}$ is the magnetic resistance of the electromagnet, A_0 the initial magnetic resistance (air and iron) the indices 1, 2, &c., correspond to the different parts, and K_1, K_2, &c., are the maxima of lines of force, reduced by considering the leakage; all coefficients can be calculated from dimensions and magnetical qualities of the different sorts of iron.

If all parts have the same section and the same iron, we have simply

$$\frac{NJ}{K} = P_0 + P_1 \frac{K}{K' - K}.$$

But also all other electromagnets, as far as the technical practice goes, can be made to obey to this formula; the coefficients P_0, P_1, K' may be calculated by the dimensions and the properties of the different sorts of iron, but also by observations taken on the electromagnet.

The formula I formerly used for the electromagnet,

$$K = K' \frac{NJ}{P_0 K' + NJ},$$

is a special case of the equation given above, viz., if $P_0 = P_1$. Therefore, the general formula covers not only the numerous cases in which my older formula agrees with the facts, but also the cases where the older formula did not agree, for instance, in the dynamo machines examined and graphically calculated by Hopkinson in his known Paper.

In the article in the *Elektrotechnische Zeitschrift*, cited above, from which these lines are an abstract, there are further given a rule for the construction of electromagnets and a new mode of calculating the loss of energy caused by hysteresis.

THE DURATION OF THE DISCHARGES OF INDUCTION COILS.*

BY H. LEWIS JONES, M.D.

In the course of an investigation into some of the properties of medical induction coils I had occasion to set up an apparatus for counting the rate of vibration of their contact breakers, and so obtained the accompanying tracings, which may be of interest to your readers, because they seem to show that the secondary discharges of induction coils are not so brief as is

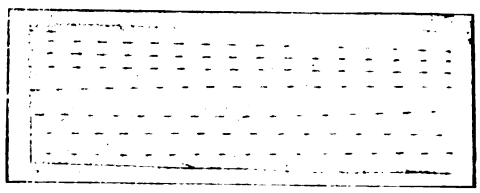

FIG. 1.—Electric Light ~ 100. Length of diagram = one-seventh Second.

generally supposed. For a particular coil Blaserna worked out the times of 0·000485 second and 0·000275 second as the duration of the make (inverse) and break (direct) discharges, and these figures are usually taken as showing that the discharges are of extremely short duration. The coil used is 7in. long and $2\frac{2}{3}$in. in diameter. Core small, $\frac{3}{4}$in. in diameter; primary

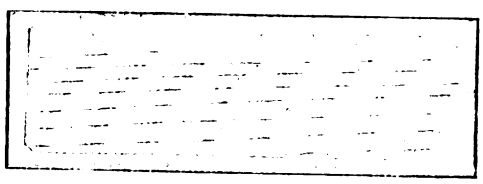

FIG. 2.—"Break" Discharges of Coil. Length of diagram = one-seventh Second.

turns 100, secondary 8,000 approximately; resistance of secondary 2,750 ohms, wound in two sections, paraffin insulated; weight of hammer, 300 grains; spring of stiff brass, $1\frac{1}{2}$in. long, $\frac{1}{2}$in. broad. Contact breaker screw close up to head of hammer, which, therefore, rebounds at once after contact, 52-55 times per second. With 4 volts and 2 amperes, gives 1in. sparks. Condenser the usual size as fitted.

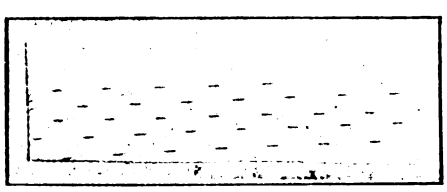

FIG. 3.—"Make" of Coil. Length of diagram = one-seventh Second.

The tracings (Figs. 1, 2, and 3) were taken upon a small revolving drum of metal covered with a strip of blotting paper wetted with starch paste containing iodide of potassium; the liberation of iodine at the positive pole strikes a dark blue colour with the starch. This reaction is much more sensitive than that of the ferrocyanide of potassium papers used in Bain's chemical printing telegraph. The drum was fixed upon

* Towards the expenses of this research a grant was made by the British Medical Association, on the recommendation of the Scientific Grants Committee of the Association

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the axle of a small electromotor, which was joined to a Young's speed indicator (Fig. 4). One terminal of the secondary coil was connected to the rotating drum, and the other to a fine platinum needle which was held against the paper by the hand and was moved from end to end of the revolving drum. The needle was bent near the end into an acute angle or elbow; this was the part used to make contact with the drum, as the point was found to scratch the soft paper. The marks made by the bent elbow of the needle were not at all elongated until the recording surface was made to move, so the shape of the markings is not due to the shape of the surface of the needle. In this way a succession of streaks and intervals was drawn in a spiral upon the cylinder. The paper was taken off the drum and the tracings were photographed at once, as the marks are very fugitive. The figures represent the strips of paper used, photographed to half-scale.*

For purposes of comparison a trace was taken from the alternating electric lighting current. This is shown in Fig. 1. Fig. 2 shows the "break" discharges (positive pole) of the secondary of an induction coil capable of giving 1in. sparks. Fig. 3 shows the "make" discharges (positive pole) of the same coil, the direction of current in the primary having been reversed. The strips are to be read from right to left, beginning at the right hand top corner.

The speed of rotation recorded was seven revolutions per second; the circumference of the drum 4½in.; the velocity of the surface 31½in. per second.

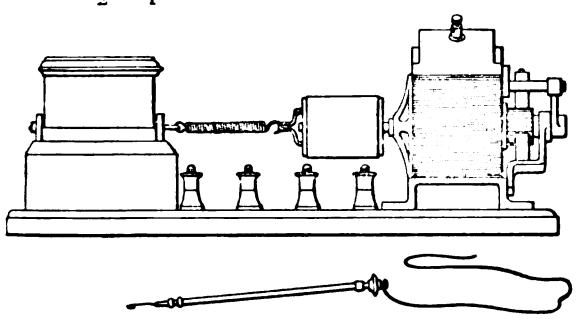

FIG. 4.—Motor, Revolving Drum, and Counter.

The rate of vibration of the contact breaker works out at 50 to 55 a second; and the rate of alternation of the electric lighting current at 112, the nominal rate of the latter being 100, I believe. The difference between these two figures is probably due to error in the indications of the speed indicator, which is a little difficult to read exactly, but it may show that the alternator at the central station was running a trifle faster than usual on the morning when the trace was taken. On another trial the rate came out at 105. Several tracings were taken on each occasion, and on each of those occasions the several traces agreed among themselves.

Measurement of the photographed tracings gives the mean duration of the discharges as follows:—

Break	0·0134 second.
Make	0·0046 „

The dotted marks at the top of Fig. 2 were caused by sparks passing though the air to the paper. It is interesting to note that they are not elongated or drawn out. The other marks are very long, and also taper off in a significant way; but no sign of this tapering appearance can be seen in Fig. 3.

The intervals in Fig. 1 (dynamo current) are longer than the marks; and from this we may reasonably infer that the method of recording does not exaggerate the length of the discharge, but rather tends to reduce its apparent duration. The resistance of the damp paper varies a good deal, but its average is rather more than 1,000 ohms.

When the make-and-break tracings are combined, and this can be done very simply by superposing their photographic negatives, it is clear that the intervals which correspond to the periods of no current in the secondary coil are very short indeed; at a rough estimate about 0·001 second, or even less in a total period of 0·019 second. At first I assumed that the short marks must be "break" discharges, and the long ones "make" discharges, but further experiments showed that this was not the case.

By substituting a mercury break for the vibrating spring contact-breaker it is possible to get single discharges, the primary circuit being made and broken by hand. When these single discharges are recorded upon the moving surface it is found that the "make" tracing does not exhibit the abrupt short character, shown in Fig. 3, but is longer and tapers away like the "break" discharges of Fig. 2. This led me to suppose that the "make" discharge was cut short by the next succeeding "break" discharge, and in order to settle this point a tracing was taken with two needles at once, one for each pole; it was then clear that the break discharge followed closely upon the make discharge without any perceptible interval at all. The character of the tracing given by both poles writing side by side (Fig. 5) is interesting. It was drawn by hand on a slip of paper, and gives a good general idea of the relations in time of the make and break discharges. It also explained why the "make" discharges had a shorter duration than the break. No doubt the character of the tracings depends a good deal upon the contact-breaker used. Some of these make a large excursion and leave the primary circuit open for a comparatively long time, while with others the primary is kept closed for a comparatively long time before it is broken again. The contact-breaker of the coil used in these experiments has a short and stiff spring, and makes very brief contacts.

The tracings of Fig. 2 show that the current at break of an induction coil discharging through a resistance of about 1,000 ohms may last as long as one-eightieth of a second. The shorter duration of the make discharge in the coil used is due to the fact that it is cut short by the establishment of a "break" current in the opposite direction.

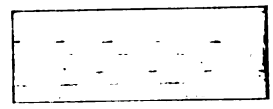

FIG. 5.—"Make" and "Break" (Positive) Discharges. To be read from left to right.

No sign of oscillation, or more correctly, no sign of alternation, can be seen in these tracings. In *The Electrician* for December 25, 1891, is an abstract of a Paper on the Induction Coil, by M. Colley, with figures of vacuum tube discharges as seen in a rapidly revolving mirror, and with curves to represent the oscillations of the discharge; though showing large oscillations, the curves do not show alternations, or changes of sign. If such had been present in my experiments the tracings should have shown them as gaps in the length of each small mark.

I should have been glad to supplement this communication with some notes on the effect on the tracings of putting a vacuum tube in the circuit; but I have not yet been able to get any satisfactory results; for the vacuum tube diminishes the current so greatly that the tracings become very faint, and the iodide of potassium paper sometimes behaves capriciously; however, a vacuum tube does seem to shorten the duration of the discharge considerably.

Tracings of smaller medical coils are essentially the same as those of the one used, the main difference is that the make marks are longer, if the contact breaker is less rigid and more springy.

* No. 3 was reduced a little too much in the camera.

THE ELECTROLYTIC EXTRACTION OF GOLD.

A Paper was recently read by Mr. J. B. Hannay, at the Institution of Mining and Metallurgy, upon a method which he has brought out for the extraction of gold from various states of ore by means of an electric current. Since the reading of this Paper we have had an opportunity to examine the extraction plant and the working of the process. Briefly stated, the principle of the process is this:—The combination of an electrolysis of a gold cyanide with the amalgamation of metallic

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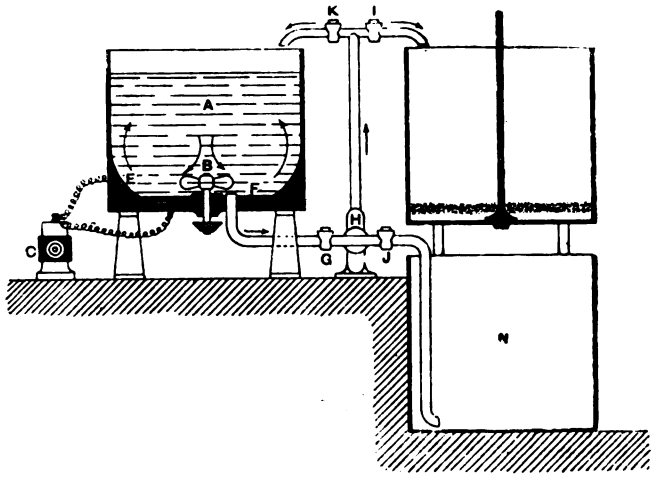
gold; that is to say, the process consists in the addition to the ordinary mechanical washing and amalgamation of an auxiliary electro-chemical process, whereby the gold which is not directly amalgamated out is dissolved in a soluble cyanide, such as potassium cyanide, and is subsequently deposited on the mercury cathode from the electrolytic salt of gold thus formed. The process is essentially two-fold, and on this account it is claimed that it will ensure a more perfect extraction of gold than in the simple amalgam process. As an example of the yield of gold by this electro-cyanide process, we may quote the figures given in the case of the Maritoto ore by Mr. Fred. Claudet. The assay of this ore indicated 12oz. 5dwt. of gold per ton, and subjection to the process we have described gave a yield of 11oz. 13dwt. 12gr. per ton, or 95·3 per cent.

The annexed diagram shows the general arrangement of the reducing plant. It consists of a wooden vat, A, fitted all round its sides near the bottom with a number of carbon plates, E, forming the anode. A mercury bath, F, at the bottom of the vat forms the cathode. Dilute aqueous solution of potassium cyanide is poured into the vat, and the ore, which has previously been crushed, but not roasted, is added. The thick, muddy liquid thus formed is kept in circulation by the mechanically propelled screw, B. An electrolysing current is generated by the small dynamo, C. The ore circulates in the



Vertical Section of Extraction Plant.

direction of the arrows, with the result that the free gold is directly amalgamated out, while the refractory gold ore is dissolved by the cyanide, forming a double cyanide of gold and potassium. This double cyanide is very shortly reduced to metallic gold and the simple cyanide of potassium, by the electric current. Thus, it will be seen that the process is cyclic in its action; the limited quantity of cyanide serving to reduce an unlimited amount of ore. In from two to six hours the charge has been exhausted. The valves G and I are opened; and the centrifugal pump, H, is set in action, transferring the liquid from the working vat, A, to the filtering vat, L. Here the liquid cyanide filters into the receiver, N, while the sludge is retained in L. To operate on another charge of ore, it is only necessary to close the valves, G and I, and to open J and K, when the filtered cyanide of potassium will be returned to the working vat, and the whole cycle of operations may be repeated. It should be mentioned that the earliest patents, under which Mr. Hannay is working his process, date back to 1886.

REPORT OF THE JOINT COMMITTEE ON ELECTRIC POWERS (PROTECTIVE CLAUSES).

The Committee have taken evidence from Sir Courtenay Boyle, K.C.B., from Mr. Preece (Engineer-in-Chief and Electrician to the Post Office), from Major Cardew (Electrical Adviser to the Board of Trade, and the Astronomer Royal. Counsel appeared before them on behalf of (1) The National Telephone Company; (2) The Railway Companies; (3) Electric Tramway Companies and Electric Underground Railway Companies; (4) Electric Lighting Companies; (5) Municipal Corporations, England and Scotland; (6) Tramway Institute of Great Britain and Ireland; and (7) Gas and Water Companies. Her Majesty's Postmaster-General was also represented, but not by Counsel.

The Committee have heard all the witnesses tendered by the several parties, and have agreed upon the following Clause, to be inserted in all Bills and Provisional Orders which authorise the Undertakers, other than Electric Lighting Undertakers, to use large electric currents, viz.:—

CLAUSE

To be inserted in all Bills and Provisional Orders which authorise any company, corporation, or person, collectively referred to as "the Undertakers," to use larger electric currents for other than electric lighting purposes. (Some modifications of form may be required to meet the circumstances of particular cases.)

(1.) The Undertakers shall, in the use of electric power under the provisions of this Act [Order], employ either insulated returns or uninsulated metallic returns of low resistance. [This clause not to apply in the case of railways, tramways, or tramroads in which the motive-power is entirely self-contained.]

(2.) The Undertakers shall take all reasonable precautions in constructing, placing, and maintaining their electric lines and circuits, and other works of all descriptions, and also in working their undertaking so as not injuriously to affect, by fusion or electrolytic action, any gas or water pipes, or other metallic pipes, structures, or substances.

(3.) The exercise of the powers by this Act [Order] conferred with respect to the use of electric power, shall be subject to the regulations set forth in the Schedule to this Act [Order], and to any regulations which may be added thereto or substituted therefor, respectively, by any order which the Board of Trade may, and which they are hereby empowered to make from time to time, as or when they may think fit, for regulating the employment of insulated returns or of uninsulated metallic returns of low resistance, for preventing fusion or injurious electrolytic action of or on gas or water pipes, or other metallic pipes, structures, or substances, and for minimising, as far as is reasonably practicable, injurious interference with the electric wires, lines, and apparatus of other parties and the currents therein, whether such lines do or do not use the earth as a return.

(4.) The Undertakers using electric power contrary to the provisions of this Act [Order], or to any of the regulations set forth in the Schedule to this Act [Order], or to any regulation added thereto or substituted therefor by any order made by the Board of Trade under the authority of this Act [Order], shall, for every such offence, be subject to a penalty not exceeding *ten* pounds, and also in the case of a continuing offence to a further penalty not exceeding *five* pounds for every day during which such offence continues after conviction thereof: Provided always, that, whether any such penalty has been recovered or not, the Board of Trade, in case in their opinion the Undertakers in the use of electric power under the authority of this Act [Order] have made default in complying with the provisions of this Act [Order], or with any of the regulations set forth in the Schedule to this Act [Order], or with any regulation which may have been added thereto or substituted therefor as aforesaid, may by order direct the Undertakers to cease to use electric power, and thereupon the Undertakers shall cease to use electric power, and shall not again use the same, unless with the authority of the Board of Trade, and in every such case the Board of Trade shall make a special report to Parliament notifying the making of such order.

(5.) The Undertakers shall take all reasonable and proper precautions in constructing, placing, and maintaining their electric lines, circuits, and other works of any description, and in using their electric lines, circuits, and other works, so as not injuriously to interfere with the working of any wire, line, or apparatus, from time to time used for the purpose of transmitting electric power, or of telegraphic, telephonic, or electric signalling communication, or the currents in such wire, line, or apparatus. Provided always that the Undertakers shall be deemed to take all such reasonable and proper precautions as aforesaid, if and so long as they adopt and employ, at the option of the Undertakers, either such insulated returns or such uninsulated metallic returns of low resistance, and such other means of preventing injurious interference with the electric wires, lines, and apparatus of other parties, and the currents therein, as the Board of Trade shall direct, and in giving such directions the Board shall have regard to the expense involved, and to the effect thereof upon the commercial prospects of the Undertaking. Provided also that at the expiration of —— years from the passing of this Act [Order] nothing in this sub-section shall operate to give any right of action in respect of, or to protect any electric wires, lines, or apparatus, or the currents therein, unless in the construction, erection, maintaining, and working of such wires, lines, and apparatus, all reasonable and proper precautions, including the use of an insulated return, have been taken to prevent injurious interference therewith, and with the currents therein, by or from other electric currents. If any difference arises between the Undertakers and any other party with respect to anything in this sub-section contained, such difference shall, unless the parties otherwise agree, be determined by the Board of Trade, or at the option of the Board by an arbitrator to be appointed by the Board; and the costs of such determination shall be in the discretion of the Board, or of the arbitrator, as the case may be.

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(6.) Nothing in this section shall apply to the use of any electric line, circuit, or work of any company, corporation, or person authorised by Act of Parliament, or Provisional Order confirmed by Parliament, to supply energy for electric lighting purposes, so far as such use is limited to such purposes.

The Committee have also agreed upon the following resolutions in the nature of recommendations, viz. :—

(1.) The Committee having regard to the evidence before them, are of opinion that it is not in the present state of electrical science to the interest of the public to insist upon electrical tramways using an insulated return conductor, and that such insistance would retard the development of electric traction.

(2.) The chief objections which have been urged before the Committee to an uninsulated return conductor are—first, the interference by leakage and induction with telephones; secondly, the interference by leakage and induction with railway signals; thirdly, the damage to systems of gas and water pipes by the action of leakage currents.

(3.) They are of opinion that the best known means of overcoming the first of these disturbances is by providing an insulated return conductor for the telephones, and they have the less hesitation in recommending this course, as the evidence shows that telephone construction is already tending in this direction, and that better results are secured to the public by the use of a twisted metallic circuit insulated entirely from the earth.

(4.) The second objection deserves serious consideration on account of the danger to the public; but the Committee are of opinion that the disturbance may be remedied at comparatively small expense by the adoption of an insulated metallic return by the railway companies.

(5.) They consider that, although electric tramway and electric railway companies should be allowed to use the wheels of carriages and the rails to complete the electric circuit, the currents should be produced and used in such a manner as to mitigate as far as is practicable any injurious effect to telephonic communication.

(6.) The Committee are of opinion that it is desirable in every way to facilitate the use of complete insulated metallic circuits for telephones, and for this end they recommend that statutory powers be granted enabling telephone undertakers to lay their wires underground.

(7.) The danger from fusion or electrolytic action appears to the Committee to have arisen from a faulty system of constructing electric tramways; and they are of opinion that it can be reduced by improved methods of construction so as to be practically negligible.

(8.) The Committee therefore recommend that the Board of Trade shall, in virtue of the powers to be conferred upon them by each Act or Order, make regulations to secure the best system of working electric tramways and railways, having regard to the expense involved by the carrying out of such regulations, and to the effect thereof upon the commercial prospects of the undertaking. The regulations to provide, *inter alia* :—

(a.) That a return conductor, if in contact with the ground, shall be of such section and resistance as to have no difference of potential sufficient to set up injurious leakage currents in the earth.

(b.) That, both with regard to the structure of the line and to the method of generation and use of the electrical current, everything shall be maintained up to the standard required by the Board of Trade; but, if the regulations are altered after the use of electric power on the line has been sanctioned, the Undertakers shall not be required to alter the structure or method of working of the line to conform to the more recent regulations, except for the public safety, or unless it shall be proved to the satisfaction of the Board of Trade that any system of metallic pipes or structures is being injured by the action of electricity escaping from the conductors, or for purposes other than public safety or injury to pipes or structures which the Board may think right, provided that the alterations do not in such last case cause substantial additional expenditure.

(c.) That all such electrical tests shall be applied to the line by the Undertakers as the Board of Trade may think necessary, and that a record of these tests shall be kept for the information of the Board of Trade.

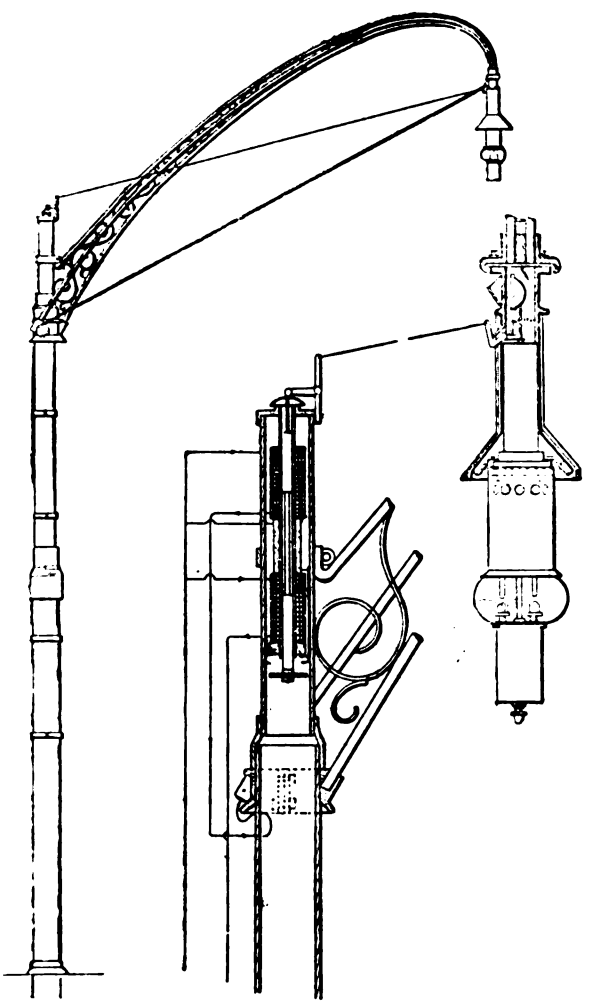
(d.) That the Board of Trade shall have all reasonable facilities for making any tests they may think necessary, in addition to those recorded by the Undertakers, to enable them to ensure the maintenance of satisfactory conditions.

(9.) That the Committee regards with apprehension a large extension of the system of overhead wires in crowded centres.

(10.) It appears to the Committee to be just that Undertakers proposing to use large currents should be required to give ample notice to those using small currents to enable them to protect themselves by insulation, and that with this view, and in reference to the clause agreed upon, a period of two years may fairly be allowed to telephone and telegraph companies from the date of the passing of any Act [Order].

A NEW STREET ARC LAMP AND POST.*

The accompanying illustration gives a clear idea of the new street arc lamp and support, invented and constructed by Rudolph M. Hunter, of Philadelphia, for the General Electric Company. The object is to reduce the weight of the lamp proper to a minimum to



enable the use of a light, graceful pole. In this lamp the weighty parts of the regulator are placed in the small tube on top of the vertical part of the post, as shown, while the lamp proper on the end of the arm contains only the carbon holders and means to feed the carbons. The regulator controls the carbons by means of a fine, invisible wire. The illustration shows clearly the construction of the lamp structure. The lamp proper is pulled into position by a light cord, and when in position it is coupled in circuit. The post is formed of tubes entirely, and is very light and strong. This lamp structure is designed to take the place of the numerous ungainly structures now disfiguring our streets. It has been exhibited in operation for some time in Philadelphia with entire satisfaction to the electric lighting fraternity.

* From the *Electrical World*.

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The Electrician.

(The Oldest Electrical Journal.)

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny

Editorial, Publishing, and Printing Offices :

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.

Telephone No. 2714. *Telegrams :* "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed "Coutts and Co."*

All Editorial letters to be addressed to the Editor.

All letters intended for insertion in "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as evidence of good faith. No notice whatever will be taken of anonymous communications.*

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THE ELECTRIC POWERS PROTECTIVE CLAUSES

The publication of the Report of the Joint Committee of Lords and Commons appointed to consider the question of the amount of protection which it would be to the public interest to afford in future to the National Telephone Company marks an epoch in the history of electric traction in the United Kingdom. Hitherto, in addition to the antipathy with which anything new is almost invariably regarded in this country, and to the undeniable unsightliness of the trolly, electric traction promoters have had to submit with the best grace they could to the onerous demands of the telephone interest. Henceforth the telephone is to have a fair field, but no favour. This is as it should be. It has never been suggested that the tractionists ought to be allowed to run their lines how and where they wished, nor denied that the working of an electric tramway would in all probability seriously disturb any single-wire telephone circuits that might be in its vicinity. The contention throughout has been that single-wire telephony was in any case quite unsuited to the conditions of urban exchange work, whilst electric traction, on the other hand, was a peculiarly effective solution of that which the Americans have aptly termed "the rapid transit problem." This being so it was thought preposterous that a bad system of telephony should be perpetuated and a valuable system of traction stamped out. To those therefore who have taken up this position the Report of the Joint Committee will be pleasant reading; since it is a victory for electric traction all

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along the line, as will be made plain by a brief glance at the proposed Model Clause.

In future it will be incumbent upon electric tramways to employ low resistance metallic returns, insulated or uninsulated, and to take all reasonable precautions to prevent electrolytic action on gas and water pipes, and disturbance of telegraphic, telephonic, and railway signal circuits; the drawing up of detailed regulations, and the settling of what are "reasonable and proper precautions" being left, as usual, to the Board of Trade, whose official motto might well be *Hic et Ubique*. It is, however, Section 5 more than any other that entitles the Joint Committee to the gratitude of the oppressed motor man. Calling to mind, it may be, the tendency of Government departments to squeeze out the very life of an enterprise by a stout rope of red-tape regulations, the Board of Trade is bidden in laying down the law governing electric traction to "have regard to the expense involved, and to the effect thereof upon the commercial prospects of the undertaking." But something still better follows. In the next sentence it is laid down that after the lapse of a certain number of years (two years are recommended) from the passing of any tramway Bill, the owners of circuits affected by the working of an electric line shall be deemed to have no ground of complaint, unless all reasonable and proper precautions, "*including the use of an insulated return*," have been taken by them to prevent injurious interference. The final section exempts electric lighting companies from the operation of the clause; an exemption which may possibly prove but a qualified benefit. The energies of the Joint Committee were not, however, exhausted by the labour of drawing up a six-section clause, and the ten "resolutions in the nature of recommendations" which follow are scarcely less satisfactory reading than the clause itself. Eminent experts might prove to demonstration "that it is not in the present state of electrical science to the interest of the public to insist upon electrical tramways using an insulated return conductor, and that such insistence would retard the development of electric traction"; but who would believe them? When, however, the amalgamated wisdom of the two Houses of Parliament preaches such a doctrine, and follows it up by pointing out that the best way for the National Telephone Company to get over its troublesome ailments is for *it* to provide insulated returns, a course which the Committee have less hesitation in recommending, "as the evidence shows that telephone construction is already tending in this direction, and that better results are secured to the public by the use of a twisted metallic circuit insulated entirely from the earth," one need not be foolishly sanguine to anticipate that the matter is set at rest. On the other hand, the National Telephone Company will, we feel certain, fully appreciate the well-meant recommendation that every facility, including the grant of statutory powers, should be given it to take its wires underground.

The outcome of this inquiry being so entirely unambiguous, the interesting question now is, will it bear fruit or remain like the battle of Blenheim, nothing more than "a famous victory." Are we to expect an electric traction boom similar to that which is now raging in the United States with all the customary transatlantic concomitants, or shall we in this, as in so many other matters of the kind, "hasten slowly," and without fuss. The latter course is, we venture to think, the more probable, as it certainly is the more desirable. One step might well be taken, namely, the embodying of the results of the Joint Committee's labours in a short general Act, thus doing away with the necessity of fifty odd separate attempts to cancel the fifty odd clauses already secured by the National Telephone Company in fifty odd existing Bills.

THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 291.)

There is another process of treating cotton so as to produce a substance practically identical with Swan's parchmentised cotton thread, which possesses several great advantages over that process. It consists in dissolving cotton wool in a solution of chloride of zinc. The viscous solution produced by this means is squirted through a small hole into a vessel containing alcohol which causes it to set and harden. The great advantage of this method is that it produces a thread of amyloid of uniform diameter throughout, and which can be made of any size, according to the size of the hole through which it is squirted, and which requires no after process of cutting down by means of draw-plates. This is a very great advantage, as the wear and tear of the draw-plates is considerable and the cost of the process is saved. The process like all others requires great care if uniform results are to be achieved. The strength of the zinc chloride solution and the amount of cotton dissolved in it must be carefully regulated, as also the temperature at which it is kept while the cotton is dissolving. There are several difficulties met with. The cotton wool when put into the solution carries down with it a quantity of air, which, as the cotton dissolves, is seen in the form of bubbles all through the solution. The solution produced is of such a viscous nature that if left to itself these bubbles will remain wherever they happen to be, or at any rate they will rise so slowly that it would be a matter of weeks for them to reach the surface. In order to get rid of them the solution is filtered and at the same time heated under a vacuum. In this way most of them may be extracted. If they are not got rid of before the solution is squirted the very small ones will remain in the squirted thread while those which are of a size equal to, or larger than, the diameter of the nozzle of the squirt, will cause a break in the thread. The smallest air bubbles are the most troublesome as their presence may not be detected until the filament comes to be lighted up, when a bright spot will appear at the place where the bubble was located. It is also very important that there should be no lumps or parts of the solution which are thicker than the rest. When these occur and arrive at the nozzle of the squirt they may retard or stop the flow, and greater pressure has to be put upon the solution to force it through. As soon as the lump is through, the thinner portion of the solution following it will run too quickly. The result is that the thread is not uniform in diameter. Constant stirring during the dissolving will prevent the formation of lumps to a great extent. Messrs. Wynne and Powell, who patented this process in 1884, give the specific gravity of the zinc solution required as 1·8 and the temperature 100°C. The material finally requires thorough washing in alcohol or water. The drying may be done in the same way as already described for Swan's process.

Parchmentised paper was proposed by Swan before his cotton process. Ordinary hard paper without any chemical treatment has also been used. In all of the above processes the carbons are produced by the carbonisation of cellulose or some modification of it. All vegetable fibres contain cellulose, cotton being nearly pure cellulose, and many of them can be carbonised and made to do for lamp filaments either with or without any chemical treatment. Bass fibre, tampico fibre, and many kinds of grass have been tried. Some of them make very good lamps, but the great objection to all of them is the want of uniformity in size and composition. It is not likely that any of them will survive as commercial lamp filaments for this reason. Edison, of course, used bamboo, and with the aid of very ingenious machinery stamped out pieces of the required size. Specimens of the bamboo in the various stages of reducing to size were exhibited at the Crystal Palace Exhibition in 1882.

Many other substances have been tried. Of animal substances silk is undoubtedly the most successful, and may

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be carbonised without any previous chemical treatment. All animal substances, however, require special precautions during carbonisation.

The process of carbonisation consists in baking the carbonisable material at a very high temperature out of contact with the air. During the process the material will shrink and become hard and stiff and take permanently whatever shape it happens to be in at the time. Special arrangements have, therefore, to be made to control the shape of the filaments. The way this is accomplished will now be described, first of all in the case of long threads as produced by Swan's process.

For making plain horse-shoe filaments the thread is wound on carbon blocks or forms. Arrangements must, however, be made for the shrinkage. The material will shrink both in length and thickness, becoming about one-third smaller. If wound on a solid carbon block and then carbonised the thread will be broken in every turn or loop. Various methods of allowing for the shrinkage have been used. The one shown in the illustration (Fig. 6) is a good one.

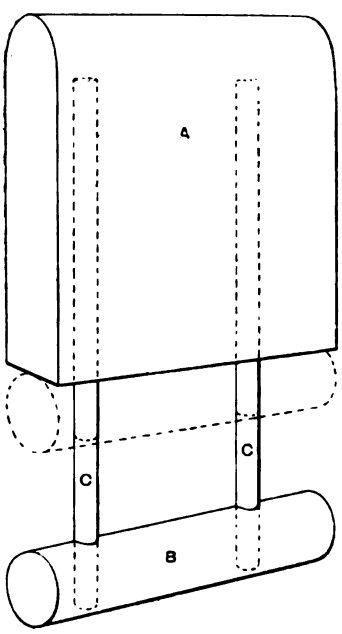

Fig. 6.

A is the carbon block with two holes about a quarter of an inch diameter drilled in it. B is a circular piece of carbon, the diameter of which is the same as the thickness of the block A. There are two holes drilled into B corresponding to those in A. At the top A should be well and smoothly rounded. A and B are connected together by sticks of hard wood C C, which may fit tightly in the holes into which they are driven home, reaching, therefore, to within half an inch or so of the top of the block. The thread is then wound round the block and end piece. It may either be wound on by hand, or the block may be clamped in a machine which will turn it round and wind it evenly, the machine feeding the block forward at the same time. When the block is filled it may be wrapped up in thin calico or paper, and it is then ready for packing in the crucible. By using the wooden sticks C C instead of a solid carbon block, the shrinkage of the thread is allowed for. The block is placed in the crucible with A uppermost, care being taken that it stands loosely and is not packed too tightly. As the process of carbonisation proceeds, the wood C C shrinks, and the block A descends at the same time that the thread contracts. By carefully regulating the temperature the thread is thus allowed to contract without being strained sufficiently to break it, but just enough to keep it perfectly straight. The length of the sticks C C is such that when the carbonisation is complete the block A will have sunk upon the end-piece B, the sticks being entirely enclosed in the holes. The illustration shows the block A and the end-piece B in position for winding on the thread. After carbonisation A and B are close together.

If it is desired to get a long filament into a comparatively short bulb, the filament may be bent round into a loop, as in the Swan lamp. This may be accomplished by simply using two of the round end pieces of the carbon blocks already described, joined together by the wooden sticks. The thread is then wound with a complete turn round the carbon at each end, the wooden sticks being long enough to allow of two filaments end to end. Instead of winding the thread straight down from one carbon to the other like the figure 0, it may be crossed like an 8. The use of solid carbon, however, is not good, owing to insufficient allowance for contraction in the loop. The thread will draw round the carbon in some degree as it shrinks, but only to a small extent, the result being that the filament is strained in the loop. This may be overcome by using split carbons instead of solid ones to wind the loop upon, as in Fig. 7.

A and B are the semi-circular carbons. C C the wooden sticks, which are smaller D D, where they pass through the holes in the carbons. Each piece A B has two other holes E E, into which are inserted short wooden sticks. In this way allowance is made for the shrinkage in the loop of the filaments as well as in the long sides.

In every process of lamp manufacture it is necessary to use the utmost care to prevent waste. Very slight differences in the ways of carrying out some of the processes may make all the difference in the result. Carbonisation is one such process. If the filaments are properly packed and handled, and the heat of the furnace is properly regulated, filaments made in the above manner may be obtained almost without loss, certainly with a breakage of not more than 2 or 3 per cent.

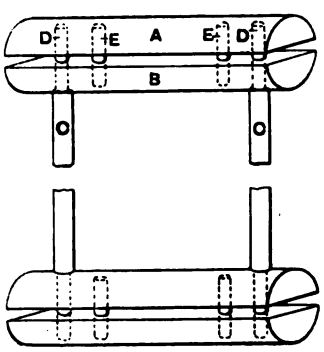

Fig. 7.

It is not sufficient, when the thread is wound on blocks in the way above described, to pack the blocks, either wrapped up or not in calico or paper, into a crucible and fill up all the remaining space with powdered carbon. The carbon powder will prevent the top part of the block from sinking during the shrinkage, and the result will be the breaking of most of the filaments. The blocks must be perfectly free to move as the shrinkage proceeds. The best way to insure this result is to use a carbon box inside the crucible. The box should be half an inch or so deeper inside than the length of the blocks when wound. A box may accommodate about ten blocks. The blocks are put in with the part A uppermost. Between each block is a thin plate of carbon about one-eighth of an inch thick. These plates slide easily in grooves in the sides of the box. By this means each block is in a separate chamber and is entirely free to move during the shrinkage. A carbon lid fits loosely on the top of the box. The whole carbon box is then put into a "plumbago" crucible of the same shape, but having a clearance of half an inch or so all round, and an inch higher than the lid of the box. The space between the box and the crucible is then filled up with powdered charcoal to the level of the top of the crucible, and the crucible lid is then put on and plastered down with fire-clay, care being taken to leave one or two small gaps in the fire-clay for the escape of the gases. If this is not done, the fire-clay may hold the lid so tightly that the gases cannot escape until a great pressure has been produced in the crucible, when the lid may be thrown violently off and the contents spoiled. No powdered charcoal is required in the carbon box, and the filaments cannot be

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burnt at all by the small quantity of air left in the box. Before the temperature of red heat, which would be required to burn the filaments, is reached, most of the enclosed air has been driven out of the crucible by expansion. The gases produced by the charring of the filaments, the wood sticks and the calico wrapping have been coming off in such volume as to sweep out practically all the remaining air, so that by the time the filaments are hot enough to burn there is no air left in the box to burn them.

Flat filaments and those which are shaped before carbonisation, of course, require a different method of packing in the crucibles. Spirals and such like forms must be packed in carbon powder or plumbago as loosely as possible, so that they may retain their shape during the shrinkage. Such a method, however, is very costly, owing to the comparatively small number of filaments which can be accommodated in the crucible. Flat filaments may be packed between layers of paper or calico with a carbon block for a weight on the top. If calico is used it should be partially charred before using, as it shrinks during carbonisation more then most filament substances.

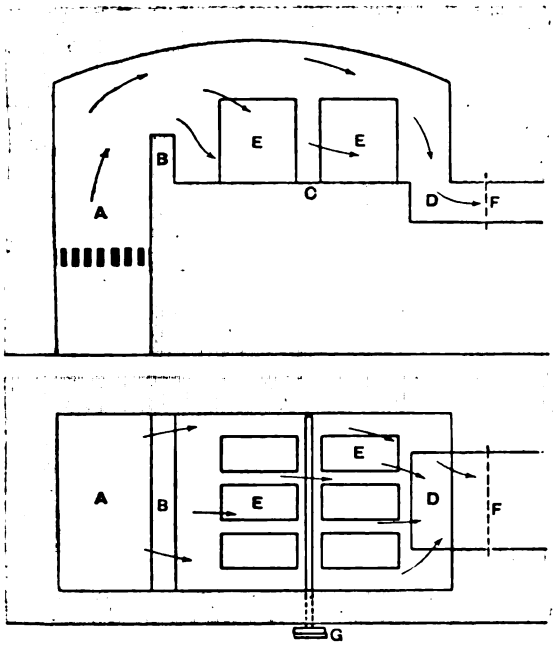


FIG. 8

Filaments of different material require different treatment during carbonisation. Some materials will allow of being heated much more rapidly than others, and some require a greater heat and more prolonged than others. Generally speaking, however, it may be said that the temperature should be raised very gradually and evenly, and should be raised as high as possible.

The construction of the furnace is also an important consideration. The fire must be in a separate chamber from the crucibles, which must not be liable to be knocked about when the fire is being stoked. It is well if the fire can be made to reach the crucibles evenly all round. This, however, is not important, provided that the temperature is at no time suddenly raised.

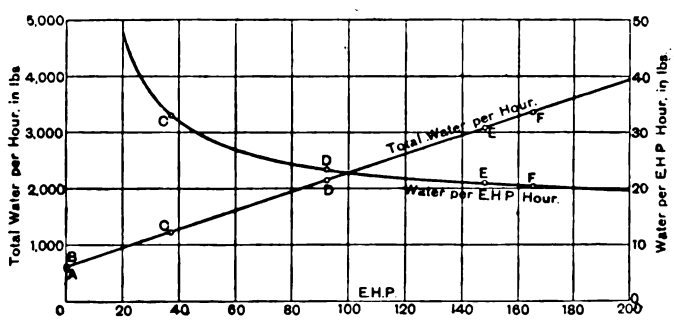
The illustration, Fig. 8, shows a form of furnace which works very well. The fire is in a chamber on the left. The hot gases pass over the "bridge," over and between the crucibles, and down through a flue into the chimney shaft.

A is the fire, B is a "bridge" of fire bricks, C is the floor of the chamber, D is the flue leading to the chimney shaft, E E are the crucibles, F is a damper in the flue D. The furnace door is made of fire-clay, and is bound together with iron. It can be raised and lowered by means of a chain and counterweight running over a pulley. The fire door can also be arranged in the same way. The furnace door has a small peephole in the centre, into which is fitted a fire-clay stopper. This hole also serves for the insertion of the pyrometer G, which is required during the first part of the process. The furnace must be substantially built with the best fire-clay bricks, and must be held together by iron tie rods and bands. The crucibles must be of the plumbago type, and the best to be had. The temperature they have to withstand is so great that they will only survive a few bakings.

(*To be continued.*)

THE PARSONS STEAM TURBINE.*

In accordance with the request of Messrs. C. A. Parsons and Co., I went to Newcastle last April, and spent two days in making a series of trials with one of Mr. Parsons's turbine-motors driving a continuous-current dynamo having an output of 150 units. The machine tested was, in external dimensions, almost exactly the same as that tested in August last by Prof. Ewing (see *The Electrician*, Vol. XXX., pp. 25 and 34); but by a rearrangement of the plates and discs its output has been very considerably increased. Its nominal maximum capacity is 150 units when working with 120lb. steam pressure, but it gave this output without apparent difficulty at 100lb. steam pressure, as will be seen below. As the motor has been so recently described, it is unnecessary that I should say anything as to its mechanical construction. The particular machine tested had six high-pressure single discs and one low-pressure double disc, the two sides of the latter being in parallel. It ran at about 4,500 revolutions per minute. The tests made were essentially directed to the determination of the quantity of steam used per electrical horse-power-hour by the motor at different loads. The water measurement was carried out by means of a little tank holding 370lb. of water (as checked by direct weighing). From this tank water was allowed to run into a somewhat larger one below it, from which the feed-pump



Feed-water Economy.

drew its supply. The feed-pump itself was worked by steam from a second boiler, which also supplied steam for the air-pumping engine. The boiler used for supplying steam to the motor was a small boiler of the locomotive type, capable of running only at 100lb. pressure. The boiler was so small for its work that there was no difficulty in keeping the feed practically continuous throughout the trials, and in keeping the water-level very steady. When running at full power the feed measuring tank lasted only eight minutes, so that it was easy to get a large number of points upon the water line in the diagram. The steam from the boiler passed through a series of superheating tubes on its way to the engine, these tubes being surrounded by the waste gases passing from the boiler to the chimney. In all the trials made, except where the engine was running light, it will be seen that there was a very considerable amount of superheating attained in this manner. It is to be regretted that it had not been found possible beforehand to make the boiler and its connections perfectly steam-tight. There were a not inconsiderable number of small leaks taking place, the total amount of which may quite well have considerably impaired the apparent economy of the motor. It was impossible for me to take these leaks, such as they were, in any way into account, and the water consumption which I give below therefore includes the whole of them, whatever they may have been. I need hardly point out that all these errors, without exception, were against the motor, and not in favour of it.

The dynamo which was used in the experiments had a continuous-current armature, not intended to take more than about 120 units.

* Abstract of a "Report on Trials of Parsons's Steam Turbine Dynamo and Alternator," by Prof. A. B. W. Kennedy, F.R.S.

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This was the largest power for which the boiler could supply steam for more than a very short time, and this fact limited the maximum power at which any water measurements could be made. The whole of the electrical measurements were made by zero methods, using a Crompton potentiometer and standard Clark cells. A standard platinoid resistance of 0·001 ohm, which was sensibly free from temperature error for very much larger currents than those which I used, was employed in connection with the current measurements. The work done by the motor was taken up upon an artificial resistance of spiral wire divided into sections to suit the different powers required. During each trial the steam pressure and water-level were noted each time the measuring tank was emptied. The temperature of the steam, the vacuum, and the speed of the engine were noted at the same time or more often. The electrical measurements were made at regular intervals of five or ten minutes, according to the duration of the trial.

On the accompanying diagram are shown graphically the results of six trials of the motor and dynamo, two running light (excited only), one at about 28 kilowatts, one at about 70 kilowatts, one at about 110 kilowatts, and one at about 123 kilowattts. These are lettered respectively in the diagram with the letters from A to F. Experiment E, at about 110 kilowatts, is the one which I looked upon as the most important, as it was run at the largest power for which the steam could be kept up for any length of time. The actual duration of the run was just over two hours, in which time 17 tanks of water were used. It will be seen from the diagram how very uniform both the power and the water were during the whole of the run, and having obtained so many points on what appeared to be a straight line, it did not appear worth while to prolong the trial further. In this trial the mean output was at the rate of 110·8 kilowatts, or 148·5 E.H.P. The boiler pressure was 94·5lb. above the atmosphere, and the average amount of superheating was 66·7° F. The average vacuum shown by the gauge was 13·95lb. per square inch, the pressure of the atmosphere being equivalent to 30·3in. of mercury, or say to 14·86lb. per sq. in. The total water used per hour was 3,094lb., which is equivalent to 27·9lb. per kilowatt hour, or 20·8lb. per E.H.P. hour.

It is unnecessary that I should go over in detail the figures obtained upon the other tests ; they are given at full length in the annexed table. An examination of the observed point, shown on the accompanying diagram, shows that for all four experiments, C, D, E, and F, the water consumption was exceedingly regular throughout the whole duration of the test. I regret that it was not possible to carry on the highest power test (F) for more than three-quarters of an hour, but at this power the boiler was very uncomfortably forced, and the armature also was being somewhat hardly treated. It will be noted, however—and this forms by far the best test of the accuracy of the water measurements—that the four points in the diagram which represent the total water used per hour follow very exactly Willans's law—that is, they lie upon one straight line. In the two trials A and B (which were made on two different days), when the motor was running empty, circumstances rendered it only possible to use one tank full of water each time. There are, therefore, in these cases no such checks afforded as in the other tests by the straightness of the water-line throughout the whole duration of the trial. The two tests, however, agree with each other very well, and the two corresponding points, as will be seen, lie very nearly in their proper place at the commencement of the line which represents the total water used per hour.

The amount of superheating appeared to depend to a considerable extent, as was natural, upon the work which was being done by the boiler—that is to say, upon the amount and temperature of the chimney gases. Running empty, there was no superheating, or rather, the superheating had fallen to nothing by the time the steam reached the engine, close to which its temperature was measured. I have no doubt that there may have been, even then, a very considerable amount of superheating given to the steam after it had left the boiler. In trial C, which was really made immediately after trial D, the superheating commenced at the point at which it had reached during D, but it will be seen that after half-an-hour it fell to a much lower point, and remained there steadily. In trials D and E the amount of superheating rose from the beginning until it attained what appeared to be a more or less normal amount for the corresponding power. In trial F the temperature was still rising when other causes (which I have already mentioned) compelled me to stop the experiment. After all the other trials were ended I had the motor run up to give an output of 150 kilowatts, in order simply to see whether it could actually deal with this load. It was impossible to keep up steam for more than a few minutes under these conditions, and therefore no water measurement could be made ; but I found that with a steam pressure falling from 100lb. down to 90lb. the motor could drive the armature with an output of 152·6 kilowatts, apparently without the slightest trouble. The vacuum at this time was 13·8lb. per sq. in., and the steam temperature had only had time to reach 380° F. when the machine was shut down. The motor was running about 4,600 revolutions per minute, as will be seen from the table.

The following table gives the principal figures, totals, and means, &c., connected with the seven-trial runs :—

Experiments on a Parsons Steam Turbine Dynamo and Alternator, Heaton Works, April, 1892.

——	A	B	C	D	E	F	G
Duration of trial, in minutes	35·5	34·0	72·0	93·0	122·0	46·5	7·0
Mean boiler pressure, lbs. per sq. in.	95·8	98·5	97·0	94·6	94·5	97·1	97·0
Corresponding mean temperature degrees F.	335·2	337·0	336·0	344·4	334·3	336·1	336·0
Actual mean steam t'mp'rature close to engine, degrees F.	330·3	331·3	356·0	371·0	401·0	391·0	380·0
Amount of superheating	...	...	20·0	36·6	66·7	54·9	44·0
Mean vacuum, lbs. per sq. in.	14·3	14·1	14·28	14·28	13·95	14·11	13·8
Mean injection temperature, degrees F.	59·0	63·3	64·4	58·6	70·7	61·7	...
Mean hot-well temperature, degrees F.	62·6	68·9	72·9	75·2	89·8	80·6	...
Mean revolutions per min.	4,268	4,385	4,480	4,475	4,655	4,625	4,592
Mean current, amperes	...	...	105·5	260·3	420·7	482·5	576·5
Mean E.M.F., volts	265·1	267·2	264·9	264·3	263·3	254·9	264·7
Mean kilowatts	...	...	27·94	68·8	110·8	123·0	152·6
Mean E.H.P.	...	...	37·45	92·21	148·5	164·9	204·6
Total water used, lbs.	370	370	1,480	3,330	6,290	2,590	...
Total water per hour, lbs.	625	653	1,233	2,148	3,094	3,342	...
Water per kilowatt hour, lbs.	...	...	44·1	31·2	27·9	27·2	...
Water per E.H.P hour, lbs	...	...	32·9	23·3	20·8	20·3	...

It is obviously not necessary for me to point out that the figures given in this table are figures of unusual excellence in economy, for they certainly rank among the best results hitherto obtained in the direct driving of dynamos by condensing machinery. The construction of the motors allows the advantage of superheating to be carried to the fullest extent, without any chance of injury to any parts of the machine, and no doubt this wise use of superheating has contributed to no small extent to the exceptionally good results which have been obtained. Since making the trials of which I have now summarised the results, I have been able to have special experiments made, with a view to determining to what extent the superheating has contributed to the result obtained. It is not necessary that I should give details as to these experiments, but their leading results may be summed up by saying that at about 35 E.H.P. the steam used without superheating was the same as with superheating, but that the difference gradually increased until at 100 E.H.P. it was about 8 per cent. The working of the boiler did not allow the non-superheating experiments to be carried farther than this, but if the same law of increase of economy held good up to the full power of the machine, its actual water consumption, as tested, must have been about 10 per cent. less than it would have been without superheating—a very notable difference. Of course this figure must be taken as only approximate, but it shows that even without superheating the motor would show very good results. I have only further to say that the engine worked throughout the trials without giving the slightest trouble in any way, either at low or at high loads. The throttle valve was full open in each case, and the engine ran upon its governor, which appeared to control it in a satisfactory manner.

THE ELECTROLYSIS OF STEAM.*

BY J. J. THOMSON, M.A., F.R.S.

(Concluded from page 293.)

Short Sparks.

I shall begin by describing the experiments with short sparks, *i.e.*, sparks from 1·5 to 4mm. long. Here the appearance of the spark shows all the characteristics of the "arc" discharge. The discharge passes as a thickish column with ill-defined edges, and when placed in a wind it is blown out to a broad flame-like appearance. For these short sparks or "arcs," as I prefer to call them, two very important laws were found to be true—

1. That within the limit of error of the experiments the volumes of the excesses of hydrogen in the one tube, and of oxygen in the other, which remain after the explosion of the mixed gases, are, respectively, equal to the volumes of the hydrogen and oxygen liberated in the water voltameter placed in series with the steam tube.

2. The excess of hydrogen appears in the tube which is in connection with the *positive* electrode, the excess of oxygen in the tube which is in connection with the *negative* electrode.

The following table contains the results of some measurements of the relation between the excesses of hydrogen and oxygen in the

* Abstract of Paper read before the Royal Society, March 9, 1893.

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collecting tubes attached to the steam tubes and the quantity of hydrogen liberated in a water voltameter placed in series with the discharge tube. The ordinary vibrating break supplied with induction coils was used, except when the nature of the break is indicated :—

Spark length in millimetres.	Metal used for electrodes.	Excess of H in tube next + electrode.	Excess of O in tube next − electrode.	H in water voltameter.	Duration of experiment in minutes.
		c.c.	c.c.	c.c.	
1·5	gold	3·25	1·5	3·2	40
1·5	platinum	2·8	1·6	3·0	30
1·5	gold	1·7	0·8	1·8	20
2·0	gold	2·0	1·08	1·95	30
2·0	gold	3·25	1·75	3·2	60
2·0	platinum	1·8	tube broken	2·0	not noted
2·0	platinum	3·0	1·5	3·0	60
2·0	gold	2·5	1·5	3·0	60
3·0	gold	1·8	not noted	1·8	not noted
3·0*	gold	0·7	0·4	0·8	90
3·0†	gold	1·6	not noted	1·75	not noted
4·0	gold	0·9	0·37	0·7	20
4·0	gold	2·75	1·25	2·7	60
4·0†	gold	1·0	not noted	1·25	not noted
4·0	gold	2·5	1·25	2·3	45

Medium Sparks.

When the spark length is greater than 4mm., the first of the preceding results ceases to hold. The second of these, that the hydrogen comes off at the positive electrode, remains true until the sparks are some 11mm. long ; but, instead of the hydrogen from the steam being equal to that from the water, it is, when the increase in the spark length is not too large, considerably greater. When the spark length has got to 8mm. this ratio begins to fall off very rapidly as the spark length increases, and we soon reach a spark length at which it seems almost a matter of chance whether hydrogen or oxygen appears in the collecting tube connected with the positive electrode.

When the sparks are at this critical length the kind of thing which happens is somewhat as follows:—For some time an excess of hydrogen (say) comes off in the tube next the positive electrode, and accumulates as the mixed gases are exploded ; then some slight change takes place in the action of the coil, and an excess of oxygen begins to appear ; this gradually wipes out the accumulation of hydrogen, and, if it goes on long enough, makes the residual gas in the tube entirely disappear ; then the oxygen begins to accumulate, only, however, to be wiped out later, when another change in the action of the coil has caused hydrogen to appear in excess in this tube. Thus, in this case, the residual gas in the tube does not, as before, steadily increase with the time of sparking, but is continually waxing and waning, sometimes being oxygen and sometimes hydrogen.

Long Sparks.

When the spark length is increased beyond the critical value the excess of hydrogen, instead of appearing as with shorter sparks at the positive electrode, changes over to the *negative ;* the excess of oxygen at the same time going over from the negative to the positive electrode. Thus the gases when the spark length is greater than its critical value appear at the same terminals, as they do when released from an ordinary electrolyte, instead of at the opposite terminals, as they do when the sparks are shorter.

The length of spark at which this reversal takes place depends, to a very great extent, upon the current sent through the steam ; the smaller the current the shorter the critical spark length. By diminishing the current by inserting a liquid resistance I reduced, on one occasion, the critical spark length from 11mm. to 8mm. This critical length, too, seems to depend upon a number of small differences not easily specified ; it will even vary greatly in the course of one afternoon, though apparently nothing has been changed. I have found, however, that this capriciousness disappears either altogether, or to a very great extent, if Leyden jars —very small ones will do—are attached to the terminals of the steam tube, or if an air break is placed in series with that tube. Under these circumstances the critical length will, if the same coil is used, remain constant from day to day.

It will be noticed that my results, when the length of the spark is greater than the critical length, agree with those obtained by Perrot and Ludeking, as these observers found that the hydrogen appeared at the negative, the oxygen at the positive, electrode. Ludeking worked with long sparks only, so that his results are quite in accordance with mine. In Perrot's experiments the spark length was about 6mm. I have never been able to reduce the critical length quite as low as this, even though I diminished the current to the magnitude of that used by Perrot ; I have, however, got it as low as 8mm., and it is probable that the critical length may not be governed entirely by the current.

I was not able to detect any change in the appearance of the spark as the spark length passed through the critical value. My observation on the connection between the appearance of the discharge and the electrode at which the excess of hydrogen appears may be summed up in the statement that when the discharge is plainly an arc the hydrogen appears at the positive electrode, and when the hydrogen appears at the negative electrode the discharge shows all the characteristics of a spark. However, before the spark length reaches its critical value the discharge looks much more like a spark than an arc.

With regard to the quantity of hydrogen liberated from the steam in comparison with that set free in the voltameter, I find that when the spark length is a few millimetres greater than the critical length the amount of hydrogen from the steam is very approximately the same as that in the voltameter. When the sparks are longer than 14mm. the amount of hydrogen from the steam was no longer equal to that from the voltameter. The results, however, were irregular, and, as mentioned before, there was a considerable quantity of nitrogen (?) mixed with the hydrogen and

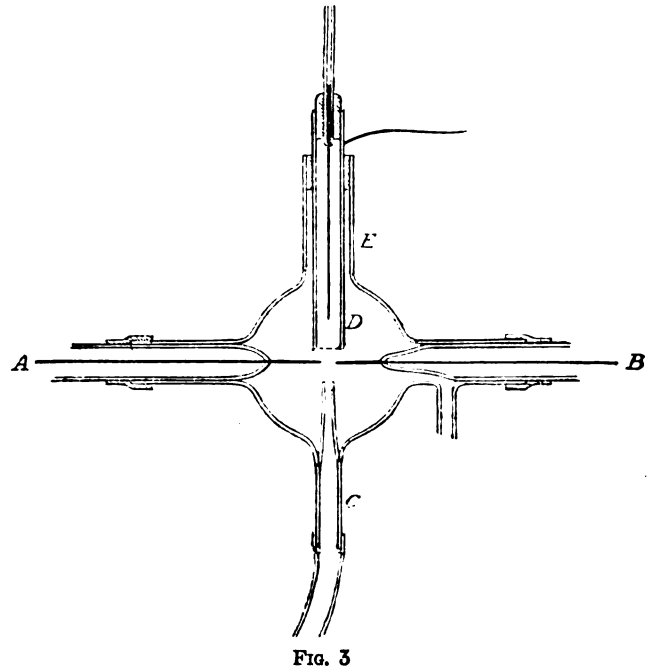

FIG. 3

oxygen. When the sparks are very much longer, say about 22mm., the electrode at which the hydrogen appears reverses again, *i.e.*, the hydrogen comes off at the positive electrode, just as it does when the sparks are very short. With these very long sparks the current is extremely small, and it takes several hours to liberate 1 c.c. of hydrogen in the voltameter. The proportion of hydrogen from the steam to that from the voltameter was with these long sparks too irregular to admit of any conclusions being drawn.

The preceding results show that in the electrolysis of steam, as in that of water, there is a very close connection between the amounts of hydrogen and oxygen liberated at the electrodes and the quantity of electricity which has passed through the steam, and that this relation for certain lengths of sparks is the same in steam as in electrolytes. There is, however, this remarkable difference between the electrolysis of steam and that of water, that whereas in the case of water the hydrogen always comes off at the negative, the oxygen at the positive electrode ; in the case of steam the hydrogen and oxygen come off sometimes at one terminal, sometimes at the other, according to the nature of the spark. The results obtained with the arc discharge, viz., that the oxygen appears at the negative electrode, the hydrogen at the positive, is what would happen if the oxygen in the arc had a positive charge, the hydrogen a negative one. As this is contrary to the commonly-received views of the electro-chemical properties of these gases, I endeavoured to see if I could obtain any other indications of this peculiarity. With this object I have made a series of experiments on the properties of various gases when the arc discharge passes through them. The apparatus used for these experiments is represented in Fig. 3. The arc discharge between the platinum terminals A B was produced by a large transformer, belonging to the Cavendish Laboratory, which transforms up in the ratio of 400

* In this experiment a slow mercury break making about four breaks per second was used.

† In these experiments large Leyden jars were attached to the electrodes.

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to 1 ; an alternating current of about 35 amperes, making 80 alternations per second, was sent through the primary of this. A current of the gas under examination entered the discharge tube through the tube C, placed underneath the arc, and blew the gas in the neighbourhood of the arc against the platinum electrode E, which was connected to one quadrant of an electrometer, the other quadrant of which was connected to earth. To screen the electrode E from external electrical influence, it was enclosed in a platinum tube, D, the end of which was made of fine platinum wire gauze, which, though it served as a screen for electrostatic action, yet allowed the gases in the neighbourhood of the arc to pass through it. This tube was connected to earth. After passing out of the tube, the electrode E was attached to one end of a gutta-percha-covered wire wound round with tin-foil connected to the earth ; the other end of this wire was connected to the electrometer.

The experiments were of the following kind :—The quadrants of the electrometer were charged up by a battery ; the connection with the battery was then broken, and the rate of leak observed. When the arc was not passing, the insulation was practically perfect, the spot of light reflected from the mirror of the electrometer hardly moving appreciably in the course of three minutes. As soon, however, as the arc was started, and for as long as it continued, the insulation of the gas surrounding E in many cases completely gave way. There were, however, some remarkable exceptions to this, which we now proceed to consider.

Oxygen.

We shall begin by considering the case when a well-developed arc passes through oxygen :—

1. When the electrode E is charged negatively. In this case it loses its charge very rapidly ; it does not, however, remain uncharged, but acquires a positive charge, increasing until the electrode E has acquired a potential V. V depends greatly on the size of the arc and the proximity of the electrode ; in many of my experiments it was from 10 to 12 volts.

2. When the electrode is charged positively. If the potential is very high the electrode leaks until the potential sinks to V ; after reaching this potential the leak stops, and the gas seems to insulate as well as when no discharge is passing through it. If the potential to which E is initially raised is less than V (a particular case being when the electrode is entirely without charge to begin with) the positive charge increases until the potential of E rises to V.

If the spark length is increased until the discharge passes as a spark then the electrode leaked slowly, whether charged positively or negatively ; the leak in this case is, however, very small compared to that which exists when the discharge passes as an arc.

Hydrogen.

When the *arc* discharge passes through hydrogen the electrode E always leaks when it is charged positively ; it does not merely lose its positive charge, but acquires a negative one, its potential falling to U, where U is a quantity that depends on the size of the arc, and on its proximity to the electrode ; in my experiments five or six volts was a common value for U. If the electrode E is initially uncharged, it acquires a negative charge, the potential falling to U while if it is initially charged negatively it leaks if the negative potential is greater than U, until the negative potential falls to U, when no further leak occurs ; if the negative potential is less than U, the negative charge on the electrode increases until the potential becomes equal to U, when it remains steady.

These experiments show that the oxygen in or near the arc discharges a negatively electrified body, but not a positively electrified one, while the hydrogen in or near the arc discharges a positively electrified body, but not a negatively electrified one. And also that an unchanged electrode becomes positively electrified in the oxygen, negatively electrified in the hydrogen.

I next endeavoured to see if this charging up of the electrodes is due to an electrification developed by the contact of the gas in the arc with the electrode, or whether this gas behaved as if it possessed an independent charge of electricity. If the electrification is due to the contact of the gas with the electrode, then it ought to disappear when the electrode is covered with a layer of a non-conductor ; if, however, the gas in the arc behaves as if it were charged, then, even though the electrode is covered with a non-conductor, the electrostatic induction due to the charge on the gas ought to produce a deflection of the electrometer in the same direction as if the electrode were uncovered. I tried, therefore, the effect of covering the electrode with glass, with mica, with ebonite, and sulphur. I found that, in all these cases, the electrometer was deflected as long as the arc existed, and that the direction was in the direction corresponding to a positive change when the arc was in oxygen, and in that corresponding to a negative one when the arc was in hydrogen. The deflection, though not so large as when the electrode was bare, was quite unmistakable. It disappeared almost entirely as soon as the arc stopped.

These experiments show that the oxygen in the arc behaves as if it had a charge of positive electricity, while the hydrogen in the arc behaves as if it had a change of negative electricity.

The following explanation of the results of the experiments on the electrolysis of steam seems to be that which agrees best with the preceding investigation. When an electric discharge passes through a gas the properties of the gas in the neighbourhood of the line of discharge are modified. Thus, as Hittorf and Schuster have shown, the gas in the neighbourhood of the discharge is no longer an insulator, but can transmit a current under a very small potential difference. Faraday's remark, that when once a spark has passed through a gas the passage of another following it immediately afterwards is very much facilitated, is another example of the same thing. We have thus good reasons for believing that when a spark passes through a gas it produces a supply of a modification of the gas, whose conductivity is enormously greater than that of the original gas. I have shown (*Phil. Mag.*, November 1891) that the conductivity of this modified gas is comparable with that of strong solutions of electrolytes. When the discharges stops this modified gas goes back to its original condition. If now the discharges through the gas follow each other so rapidly that the modified gas produced by one discharge has not time to turn to its original condition before the next discharge passes, the successive discharges will pass through this modified gas. If, on the other hand, the gas has time to revert to its original condition before the next discharge passes, then the discharges pass through the unmodified gas ; we regard this as being accomplished by means of successive decompositions and recombinations of its molecules, analogous to those which, on Grotthus's theory of electrolysis, occur when a current passes through an electrolyte.

From this point of view, the explanation of the results of the experiments on the electrolysis of steam are very simple. The modified gas produced by the passage of the discharge through the steam consists of a mixture of hydrogen and oxygen, these gases being in the same condition as when the arc discharge passes through hydrogen and oxygen respectively, when, as we have seen, the hydrogen behaves as if it had a negative charge, the oxygen as if it had a positive one. Thus, in the case of the arc in steam, the oxygen, since it behaves as if it had a positive charge, will go to the negative, while the hydrogen, behaving as if it had a negative charge, will go to the positive electrode. We saw that this separation of the hydrogen and oxygen took place. The correspondence between the quantities of hydrogen and oxygen from the electrolysis of the steam and those liberated by the electrolysis of water shows that the charges on the atoms of the modified oxygen and hydrogen are the same in amount, but opposite in sign to those we ascribe to them in ordinary electrolytes.

PARLIAMENTARY INTELLIGENCE.

The Dublin Southern District Tramways Bill.

The Dublin Southern District Tramways Bill came before the Select Committee of the House of Commons, over which Mr. Samuel Hoare presided, on Friday last. The object of the Bill is to authorise the use of mechanical power in the working of the Dublin Southern District Tramways, and to enable the Company to acquire the undertaking of the Blackrock and Kingstown Tramways Company.

Mr. Crippe, Q.C., and Mr. J. D. Fitzgerald appeared for the promoters, and Mr. Pembroke Stephens, Q.C., and Mr. Clifford, for the petitioners against the Bill, the Dublin, Wicklow, and Wexford Railway Company.

Mr. CRIPPS, in opening the case for the promoters, said the point n dispute between the promoters and their opponents was a very narrow one. Really, the only point was what form of protective clause should be inserted in the Bill in order to ensure that no damage should be done to the Railway Company's railway signals by the use of electrical power along the tramway lines.

At this point a proof of the Joint Committee was produced, and

Mr. CRIPPS read the Model Clause. He would ask the Committee under these circumstances not to ask them to call expert witnesses at enormous cost and to go over the case again.

Mr. PEMBROKE STEPHENS said there were other points at issue besides that of the protective clauses. The petitioners urged that powers to work the tramways by mechanical or electrical power was in contravention of the express provisions in the Act authorising this tramway, the Act only being passed by Parliament under the provision that the tramway should be worked by horse-power. They futher submitted that it would be in contravention to the Order in Council of the Lord Lieutenant, and that the working of this tramway by electricity could not fail to inflict injury on the petitioners. This tramway ran absolutely parallel with the railway, almost touching at some points. He accepted the model clause as far as it went, but the main point was whether this Company should have electrical power or not.

Mr. CRIPPS said he would call evidence on that point. Mr. Spagnoletti and Mr. Alexander Siemens having been examined, Mr. PEMBROKE STEPHENS urged that if the Committee were going to pass the Bill, at least they should insure that there should be a proper local inquiry and

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safeguard before anything was done, so as to prevent any mischief happening.

Mr. W. L. PAYNE (General Manager of the Dublin, Wicklow, and Wexford Railway Company) was then called. He said the wires by which the singles were worked would be parallel with and very close to the proposed overhead wires for the tramway. The tramway crossed the railway. They were in an exceptional position in Ireland in reference to the main block signal stations. The staff were under Witness's control, but the maintenance was taken charge of by the Post Office. He considered that the Model Clause did not in this case give the Railway Company sufficient protection. He thought that the proper maintenance of the Tramway Company's electrical system would depend to a great extent upon its financial position, and if that did not become better than it was at present, it would be a very bad look out. He thought it a great hardship that the Railway Company should not have an opportunity of being heard before the Board of Trade before the use of electricity was sanctioned upon this tramway.

Cross-examined, WITNESS said the block system on the Dublin, Wicklow and Wexford Railway was the best in the country.

Mr. LANGDON (Superintendent of the Electrical Department of the Midland Railway) gave scientific evidence with regard to electric traction, and said if they had a tramway worked by the electrical system they must have proper protection.

Mr. HARRISON (General Manager of the London and North-Western Railway Company) was called next, and said if he were responsible for the conduct of the Dublin Railway Company he should view the introduction of this electric tramway with the very greatest apprehension. If there were the slightest possibility of the smallest interruption with railway signals it would be a very serious matter.

Mr. CRIPPS replied on behalf of the promoters. Mr. CLAY (Solicitor to the Promoters) was then called to give formal proof of the uncontested portion of the preamble. After consultation with his colleagues, the CHAIRMAN announced that the Committee had decided that the preamble was proved, and they understood that model clauses would be put in the Bill.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 7, 1893.

Incandescent Lamp Litigation.—Another chapter in incandescent lamp litigation has been begun at Milwaukee (Wis.). The suit now being tried there is an application for an injunction against a small lamp company, but the real defendants, as in the St. Louis case, are the lamp manufacturers who are attempting to break up the General Electric Company's lamp monopoly. A great deal of bitterness is being shown in the present case, and counter charges of bribery and perjury are being made. The plaintiffs charge fraud and perjury in regard to the Goebel evidence, and the defendants charge bribery of Henry Goebel, jun. New points have been made by each side, and at the time of writing it is impossible to give any indication as to the final result.

Electric Traction Franchises.—The great expansion of electric traction has brought into strong relief the disgraceful state of municipal government in the United States, as well as the ease in which corrupt measures may be passed through our legislative bodies. In all of the larger cities electric traction is almost entirely in the hands of corrupt politicians, and many of our notorious political bosses are becoming opulent through their control of street railway franchises. In New Jersey recently a threat that the Governor would suspend certain officials was necessary to put an end to the free gift of valuable franchises. In Brooklyn, the mayor and aldermen were only prevented from being indicted by the grand jury by the discovery that a Bill had been passed by the legislature, putting the offence charged under the sole jurisdiction of police justices, who are tools of the ring. Altogether the seeking for franchises through electrical development has brought to light a state of political corruption that is disheartening. The only encouraging feature is that the leaders, almost to a man, are of foreign birth.

The Working of Lock Gates by Electricity.—The chief engineer of the Dominion canals states that tests of the applicability of electricity to the working of lock gates are being made on the Beauharnois Canal, and should they prove satisfactory, electrical appliances will be adopted in connection with the Canadian Canal at Sault Ste. Marie, water-power from the canal being used to generate the electricity. The result of the tests on the Beauharnois Canal will be known shortly.

CORRESPONDENCE.

MEASURING MAGNETIC FIELDS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The writer of the Note on "Measuring Magnetic Fields," which appeared in your issue of July 14th, appears to have been misled by the use there made of the symbol H.

Instead of making H denote the horizontal intensity of the earth's field, Mr. Russell uses it to represent the horizontal intensity of a magnetic field, where the effect of the earth's magnetism is interfered with by masses of iron or other disturbing elements, and where the lines of force can hardly be considered parallel relatively to a magnet but a few inches long. In such a field errors of very appreciable magnitude would be involved in a measurement made with an ordinary magnetometer, of which the needle is necessarily much larger than that used by my colleague.

I do not think Mr. Russell claims any theoretical advantage for the one he described over the tangent galvanometer method, but, in places where there are big masses of iron lying about, and currents of a magnitude generally measured on an ordinary ammeter are used, tangent galvanometers are not, as a rule, to be found, and the practical advantage of a method in which the only additional piece of apparatus required is an ordinary charm compass is a very distinct consideration.—Yours, &c.,

HUGH ERAT HARRISON.

Faraday House, Charing Cross-road, W.C.,
July, 18, 1893.

INSULATING WATER PIPES BY PAINTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the evidence given before the Committee on the Electrical Powers Protection clauses, Sir Frederick Bramwell mentioned that the paint on water pipes would act as an insulator. The following experiment will, I think, show that the value of such insulation is extremely small. In a water resistance consisting of two lead plates in a solution of sodium sulphate, one of the plates was painted with a paint much used for electrical purposes, consisting chiefly of bituminous compounds, and asserted to be an insulator. The surface painted was about $3\frac{1}{2}$ sq. ft. When perfectly dry it was coupled up to a dynamo giving a pressure of 60 volts, and a current of 100 amperes was obtained through the paint, the resistance of the cell being only slightly increased by the painting. This current was kept on for about 15 minutes, and on stopping the paint was found to be hardly damaged, the only part affected being the terminal where the current entered the cell. This shows that in the large area of a water pipe the paint would be absolutely useless in preventing the flow of electricity from the earth to the pipe, or *vice versâ*.—Yours, &c.,

University College, Liverpool. FRANCIS G. BAILEY.

[Our correspondent has hardly reproduced the conditions of actual practice, for he substitutes a strong salt in the solution in place of the soil, and uses a higher voltage than might in practice be expected to occur. It also appears that he neglected to prevent contact of the electrolyte with the negative pole, as corrosion at this part was observed. A similar test carried out on a hundred yards of pipes covered with Angus Smith composition, in damp soil, would be of considerable interest.—ED. *E.*]

USEFUL FORMULÆ.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following simple rules will be found useful when a wire list is not at hand:

$$\sqrt{\text{current}} = 28 \times \text{diameter in inches.}$$

This is on the basis of 1,000 amperes per sq. in. for round copper wires.

$$\text{Resistance per mile} = \frac{0{\cdot}05617}{(\text{diameter in inches})^2}$$

Yours, &c., F. O. HUNT.

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THE EASTBOURNE ELECTRIC LIGHT COMPANY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has just been directed to the speech of Mr. Denny Lane, M.A. (the President of the Incorporated Gas Institute), at the annual meeting of that body, recently held at Belfast, and also to his letter published in *Lightning* of July 6th, in both of which he refers to the Eastbourne Electric Light Company. I should not have noticed Mr. Lane's remarks had they been either just, generous, or in accordance with facts, but as they are neither and contain allegations against myself, I feel bound to notice them. At the outset I say most emphatically that neither the Directors of the Company nor myself have ever attempted to keep to ourselves or otherwise suppress or conceal the position or accounts of the Company, but for the information of Mr. Lane I propose to give the *facts* upon which his remarks and allegations are apparently founded.

The last annual meeting of the Company was held in February, and prior to the meeting the report and accounts were issued to the shareholders and debenture-holders, *and a copy thereof was sent to each of the five local journals, and also to the electric lighting journals for publication.* Before the holding of the meeting summaries of the report and accounts appeared in a number of publications, and there were several reporters present at the annual meeting, full reports of which were published. The Directors were, and are, proud of the position the Company has attained. It was the first established in England for the supply of electricity from a central station, and as the pioneer of electric lighting companies it has necessarily spent a large sum in experimental working, and its capital is thus somewhat larger than it would otherwise have been.

Some weeks subsequent to the annual meeting Mr. Hammond, the manager of the Eastbourne Gas Company, called upon me with reference to some business. In the course of conversation the Electric Light Company was referred to, and Mr. Hammond asked me if I had any objection to give him a copy of its last published accounts. I said, "None whatever;" and I added that a copy should be sent him in a few days as I had none at hand. I was not aware at the time of the approaching meeting of the Incorporated Gas Institute, or even of the existence of that august body, otherwise I might have drawn some inference as to the purpose for which the accounts were required. Being an extremely busy man, and having an unusually heavy pressure of work at the time, Mr. Hammond's desire to be supplied with a copy of the accounts for the moment escaped me, and before it recurred to my mind I was waited upon by Mr. Peters, a gentleman from the Gas Company's office, *demanding to be supplied under the provisions of the Companies Acts with a copy of the last annual accounts of the Company, for which Mr. Peters stated he was prepared to pay or tender me the usual fee, which he fixed at 1s.* I replied that I knew the Companies Acts pretty well, but I was not aware that any person had a right to *demand* a copy of the accounts; but I was quite prepared to give one. The demand was such an unusual one that I asked Mr. Peters if he sought to obtain the accounts for himself. He said "No." I then inquired if it was for the purposes of an appeal which my Company is prosecuting against its assessment. Mr. Peters replied "No." I then pressed him to tell me from whom the demand came, and after some hesitation he told me he had requisitioned me on behalf of Mr. Hammond (the manager of the Gas Company). I said, "I am astonished at this, as I have promised Mr. Hammond a copy of the accounts, and should have sent it; but," I added, "having regard to the course which has been pursued, I consider I am released from this promise." Before Mr. Peters left I said, "show me under what Section of the Companies Act Mr. Hammond demands the copy of the accounts, and he shall have it." The Section has never been pointed out to me, and I am now charged with refusing to *give* a copy of the balance-sheet to a ratepayer who has contributed his quota to the public lamps, and with a foolish attempt to conceal what could not be hidden. Self-respect alone dictated the only course I could pursue, and I leave your readers to judge whether Mr. Lane's allegation that there has been any attempt to conceal the position of the Company is either honest, honourable, or true.

Mr. Lane is correct in stating that this is the first year in which a dividend has been paid to the shareholders, but he endeavours to manipulate the figures of the balance-sheet so as to show that only £431 has resulted from last year's trading, including sums received for installation work and tuition fees. This is a fabrication. The total profit earned for the year ended December 31, 1892, was £1,746. 2s. 11d., of which £400 was written off for depreciation of plant and machinery, £1,074. 9s. 7d. was absorbed by the payment of interest at £5 per cent. upon the Company's debenture capital, a further sum of £73. 12s. 5d. was also paid for interest on mortgages and debentures redeemed, leaving a balance of £198. 0s. 11d., and with this and a balance earned upon the 1891 working after the payment of debenture interest, a dividend of £3 per cent. has been paid upon the Preference and Ordinary share capital of the Company. Mr. Lane ignored the debenture capital, upon which interest is regularly paid at £5 per cent. I assume debentures are (except, perhaps, in a technical sense) as much the capital of a company as share capital. Mr. Lane's figures are a miserable perversion of facts, and did he not attempt by his letter to justify the remarks contained in his speech, it would be charitable to suppose his brief perusal of the accounts had led him into error. But between the annual meeting of the institute and the date of his letter he had ample time to digest the figures. The fact is that after payment of all working expenses, and allowing for the two sums of £169 and £25, to which Mr. Lane alludes, my Company netted as the result of its operations for 1892 £1,552, or, to be accurate, £1,551. 13s. 9d. I question whether gas companies did better in their infancy.

I am somewhat amused at Mr. Lane's cynical remark as to the unseaworthiness of the craft which my Directors steer. I can only say the craft now sails upon an even keel before the wind of popular favour, and its course, so far as I know, is clear of all shoals, breakers, and quicksands. I judge from the tenacity with which the shareholders hold to their shares that they are also well satisfied with their craft. There is plenty of room for both gas and electricity, and the latter will advance to a front rank, despite the attacks and opposition of the votaries of the former.—Yours, &c., H. TOWNER, Secretary.

Eastbourne, July 15, 1893.

LEGAL INTELLIGENCE.

Blackie v. Electricity Supply Corporation (Limited).

The further hearing of this case was resumed on Friday last by Mr. Justic Cave and a special jury. Several additional witnesses were called for the defence to state that they were unable to detect any appreciable vibration in the neighbourhood of the plaintiff's premises or of the defendants' works.

Mr. MOULTON and Mr. BOUSFIELD addressed the jury, and the learned JUDGE, in summing up, said that when a person made use of his land in a way differing from others round about he must take care not to inflict injury or discomfort on others. In this case the defendants clearly were not doing what people all round were doing. The test was had the defendants done anything which had made the enjoyment of the plaintiff's house uncomfortable, or had they seriously interfered with the plaintiff's carrying on his business? If either had happened, then the plaintiff was entitled to a verdict. If neither had happened, then the defendants were entitled to a verdict. It was said that the defendants had communicated vibration to plaintiff's property. If they had done that so as to substantially interfere with his comfort or his business, then the plaintiff would be entitled to a verdict. The plaintiff had two strings to his bow—first, an alleged interference with his comfort; secondly, an interference with his business.

After a retirement of an hour and a-half, having in the interval sent a message to the Judge that they were unable to agree, the jury returned a verdict to the effect that they found there was vibration upon the plaintiff's premises, but that it was of so slight a character as not to materially interfere either with the ordinary enjoyment of his house or with the conduct of his business.

His LORDSHIP said this was a verdict for the defendants, for whom he gave judgment, certifying for a special jury.

BOOKS RECEIVED.

"Captain Enderis." By Archer P. Croucher. Vols. I and II. (London: W. H. Allen and Co.) Price 21s.

"Electric Light Fitting." Second Edition. By John W. Uppuhart. (London: Crosby Lockwood and Sons.)

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TRADE NOTES AND NOTICES.

Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

The 1893 Edition of "THE ELECTRICIAN" Electrical Trades' Directory and Handbook is NOW READY. This useful book contains over 1,000 pages, and several new and handy features have been added. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

TENDERS INVITED.—The Richmond (Surrey) Town Council invite tenders for the supply and laying of fire-calls within the borough. Specifications and forms of tender are to be obtained from Mr. F. B. Senior, the town clerk, to whom tenders must be delivered by 2 p.m. on Wednesday, the 2nd prox. Further particulars appear in our advertisement columns.

——— The Electric Lighting Committee of the Halifax Corporation are prepared to receive tenders for the supply of three boilers. Specifications and forms of tender are to be obtained from Mr. T. P. Wilmshurst, the borough electrical engineer, and tenders must reach Mr. Keighley Walton, the town clerk, by 10 a.m. on Friday, the 4th prox. Further particulars appear elsewhere.

——— The Cardiff Corporation require about 150 tons of cast-iron pipes and about 200 draw and junction boxes, tenders for which must be in by Wednesday next.

TENDERS RECEIVED.—The following were the tenders received by the Portsmouth Town Council for the supply and laying of the electric lighting mains :—

Messrs. Reid Bros.	£15,244
Messrs. W. T. Glover and Co.	15,221
W. T. Henley's Telegraph Works Company (Limited)	14,579
Messrs. Siemens Bros. and Co. (Limited)	13,407
India-Rubber, Gutta-Percha, and Telegraph Works Company (Limited)	12,712
Callender's Bitumen, Telegraph, &c., Company (Limited)	12,537
International Electric Subway Company (Limited)	12,043
British Insulated Wire Company (Limited)	11,673

As stated in *The Electrician* last week, the tender of the International Electric Subway Company was accepted, the total amount (inclusive of all accessories) being £13,539.

TENDERS ACCEPTED.—The tender of Messrs. Drake and Gorham has been accepted by the Richmond Main Sewerage Board for providing and fixing the necessary apparatus for lighting their works at Mortlake by electricity.

——— The Police Commissioners of Moffat have accepted the estimate of Messrs. Woodhouse and Rawson United (Limited), of Glasgow, for installing the electric light in the burgh, at a total cost of £4,000. The power will be derived from the falls at Skellywell, on the River Evan, nearly two miles from Moffat.

——— The tender of Mr. F. M. Newton, of Taunton, has been accepted for the lighting of the Dorset County Asylum. The installation consists of about 1,000 incandescent lamps. Taunton dynamos will be used, coupled direct to Willans high-speed engines.

SALE BY AUCTION.—Messrs. Wheatley Kirk, Price, and Goulty announce a sale on the 26th inst. of engines, boilers, shafting, steam-hammers, machine tools, and plant at the Canal-street Ironworks, Derby, the sale to commence at eleven o'clock for twelve o'clock prompt. Catalogues are ready, and can be obtained of the auctioneers, 49, Queen Victoria-street, London, E.C., or Albert-square, Manchester.

PLANT FOR SALE.—Mr. Thomas Oliver, of Totley, near Sheffield, has for sale an electric light plant, comprising a compound-wound Silvertown dynamo, a main switch and fuse-board, some cable and fittings, and a number of lamps, for further particulars of which see advertisement columns.

BANKRUPTCY.—Thomas Fletcher, electrician, of 188, Broadhurst-gardens, West Hampstead, has been adjudicated a bankrupt.——Proofs of debts against Frederick G. Robinson (separate estate), electrical engineer, of 97, Leopold-street, Kensington, Liverpool, must be in by August 2nd to Mr. A. Thraves, 15, Victoria-street, Liverpool.

APPOINTMENT.—Messrs. Urquhart and Small have been appointed electrical engineers for the borough of Richmond (Surrey).

——— Mr. G. F. Metzger, chief engineer of the Bath Electric Lighting and Engineering Company, has been appointed general manager in the place of Mr. Massingham, who has resigned that position.

MR. F. ESPIR.—We learn that Mr. Espir has been appointed sole agent in Great Britain and Ireland for the Budapest Incandescence Lamp Company.

CHANGES OF ADDRESS.—The registered offices of the Electric Construction Company (Limited) are now at Queen-street-chambers, Queen-street, Cheapside, E.C.——In consequence of the disastrous fire in St. Mary-axe, Messrs. Davis and Soper, the agents of the Johannesburg Lighting Company, have taken offices at 6, Great Winchester-street, E.C.

CHELSEA ELECTRICITY SUPPLY COMPANY (LIMITED).—This Company have completed the laying of mains and are now supplying current in the following streets, which were lately added to their area of supply :—Cheyne-gardens, Cheyne-walk, Chelsea-embankment, St. Leonard's-terrace, Tedworth-square, Tite-street, Ralston-street, Durham-place, Oakley-street, King's-road. Large additions to the Company's plant and further extensions of mains are being made.

MR. E. LANSARD.—We have received printed particulars of a "New Electrical Combination Contact and Switch with Automatic Replacement," manufactured by Mr. Lansard, who is the inventor and patentee. Mr. Lansard claims that this combination dispenses with expensive switches and also with the inconvenience of getting to the switch. Any single door or call may be used or switched off without disturbing any other part of the installation, and the switch is automatically brought into its normal position by the closing of the door.

CROSSLEY'S "OTTO" GAS ENGINE.—We have received from Messrs. Crossley Bros. (Limited) an intimation that new sheets of price-lists, showing the reduced prices of their engines, can be obtained on application at Openshaw, Manchester, or at the numerous branches throughout the country.

FORTHCOMING BOOKS.—Messrs. Whittaker and Co. announce a "Manual of Telephony," by Mr. W. H. Preece and Mr. A. J. Stubbs, which will be ready early next month. The book will consist of about 500 pages. A large number of original illustrations have been prepared for the book.

"SCREWS AND SCREW MAKING."—We have received from the Britannia Company a copy of a new work under the above title, which will be found of considerable interest to those engaged in engineering pursuits. The work is well illustrated—of course, chiefly with illustrations of the tools and machines made by the Britannia Company—and it also contains a variety of tabulated and general information which will be found serviceable by many of our readers.

"ADRESSBUCH DER ELEKTROTECHNIK."—We have received from Herr A. Balck a list of German electrical firms arranged in towns, which forms a useful appendix to his "Adressbuch" published last year, and of which it is to make a third part.

HOLIDAY TRIPS.—We have received a copy of the summer number of the *Western Morning News* (price 2d.), containing illustrated descriptions of the watering-places in the West of England, with a very complete list of conveyances, which will be found of special interest to intending visitors to these popular resorts. This is a new journalistic departure in the West, and great credit is due to Mr. Ernest Croft for its production.

THE EDISON AND SWAN COMPANY.—The annual excursion of the *employés* took place on Saturday last, when about 600 went to Hastings, where an enjoyable day was spent. After a pleasant morning, about 400 sat down to dinner in the public hall, the company including the Manager of the works (Mr. Edward Gimingham), who occupied the chair, Messrs. P. H. Bell, C. M. Downie, Mancur, W. Young, A. W. Hill, A. Abercrombie, C. Faraday Proctor, A. H. Bate, Cooke, and others. In the evening about 100 of the female hands were regaled.

ABERDEEN.—Out of the applicants for the post of City Electrical Engineer four names—those of Messrs. John Christie (Glasgow), Alfred H. Gibbings (Hove), E. T. Ruthven Murray (Larne), and Fred. A. Nixon (London)—have been selected from which to make a final decision on August 7th.

BEDFORD.—The Bedford Electric Light Company (Limited) notify the Corporation that they intend applying to the Board of Trade for a Provisional Order authorising them to supply electricity within the Council's district.

BROMLEY.—The Local Board at their last meeting resolved to borrow £3,175 for the purchase of land in Station-road as a site for the electric lighting station.

CHATSWORTH.—This famous Derbyshire mansion is being fitted with the electric light under the supervision of Mr. B. Drake, who proposes to utilise the water-power already laid on for the supply of the fountains, from which source he estimates he can obtain 150 H.P. for the generation of the electric light. The installation, which will be one of the largest examples of the utilisation of water-power for country house lighting, is expected to be completed by the end of September.

CROYDON.—At the last meeting of the Town Council the report of the Electric Lighting Sub-Committee recommending that the Council carry out the lighting of the compulsory area in accordance with Mr. Preece's report, at an estimated cost of £25,000, was under consideration. After some discussion the Council voted, when

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there appeared an equal number for and against the adoption of the report, and in the end it was referred back to the Committee for further consideration.

DUNDEE.—Electricity is being developed in Dundee as a motive-power as well as an illuminant, several tradesmen having had small motors fitted up for use in connection with their businesses.

GUILDFORD.—The Holloway Electricity Supply Company (Limited) have notified the Urban Sanitary Authority that they intend making application for a Provisional Order for empowering them to supply electricity at Guildford.

HAMMERSMITH.—At the last meeting of the Vestry the Electric Lighting Committee reported that they had appointed a sub-committee to go into the whole of the question of electric lighting generally, and to report thereon.

HUDDERSFIELD.—The parish church is being installed with the electric light.

LAMBETH.—The Vestry decided at a meeting last week to defer taking any action under their Provisional Order for six months.

LEEDS.—The desirability of acquiring new plant for the electric lighting installation of the Leeds Municipal Offices and Town Hall is under consideration, the existing machinery being now inadequate for maintaining the light at its proper standard. The probable outlay would be between £10,000 and £12,000.

SHEFFIELD.—At the last meeting of the City Council, on a motion for the approval of the minutes of the Highway and Sewerage Committee, Alderman Carter called attention to a resolution of the Committee dealing with the construction of transformer chambers by the local Electric Lighting Company, and charging a rental for many of them. He moved an amendment that the matter be referred back to the Committee for reconsideration, as he did not see why this Company should be placed on any different footing from the Gas Company. The Deputy Town Clerk having given his opinion that a charge for these chambers could not be legally enforced, the amendment was carried.

SHREWSBURY.—The Shrewsbury Electric Lighting Company (Limited) have notified the Town Council of their intention to apply for a Provisional Order empowering them to light the town by electricity. A resolution has been carried by the Council extending the period during which they would have the right to purchase the works from seven or fourteen years to twenty-one, but the final discussion of the question is adjourned.

WESTON-SUPER-MARE.—At the last meeting of the Town Commissioners it was resolved to request the Brush Electrical Engineering Company (Limited) to make an offer to the Board for the purchase of their Provisional Order for a term of years, and also to submit a tender for the erection of works for the supply of electricity, together with an approximate estimate of outlay necessary, supposing the Board were to undertake its own works.

WINCHESTER.—The Town Council of the City of Winchester have appointed Messrs. Morgan Williams and King, consulting engineers, to adjudicate in the matter of the award of the premium offered for the best scheme delivered to them for the electric lighting of the city.

WINDSOR.—At the last meeting of the Town Council the Town Clerk read some correspondence which had passed between the Board of Trade and the Windsor and Eton Electric Light Company (Limited), in which the Board requested the Company to forward reasons why their Provisional Order should not be revoked. The solicitor to the Company had replied that they had every hope before very long of being able to obtain the necessary further capital, and to extend their operations, and requested the Board to allow the question of revocation to stand over for the present. The Town Council eventually appointed a committee to seek an interview with the Electric Light Company officials with the object of ascertaining whether the Company would soon be able to comply with the Board of Trade requirements.

WOLVERHAMPTON.—The Local Government Board will hold an inquiry on Wednesday next at the Town Hall, Wolverhampton, respecting the application of the Town Council for sanction to borrow, amongst other amounts, £1,927 for electric lighting purposes.

The Candle-Power of Arc Lamps.—It was recently stated that independent tests of 23 arc lamps in the streets of Buffalo (N.Y.) had revealed the fact that the so-called 2,000 c.p. lamps gave, on an average, only 807½ candles. The electric light company has now replied to this by publishing the results of tests made on its behalf by a committee composed of two professors and a doctor. This committee tested over 100 lamps, and the results obtained were all well above 2,000 candles; some of them were nearer 3,000 candles.

PATENT RECORD

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

June 13, 1893.

11,609. J. F. MCELROY. London. Improvements in electric switches.*

11,610. C. J. YARNOLD. London. Improvements in apparatus employed in the evolution and collection of hydrogen and oxygen gases by electrolysis

11,622. R. H. SANDERS and C. T. THOMPSON. London. Process of magnetic separation and apparatus adapted to the conduct of such process.*

11,649. Sir C. S. FORBES (Bart.). London. Improvements in apparatus for facilitating telephonic intercommunication.

June 14, 1893.

11,680. F. SAUER and C. AEUTZCHEL. Manchester. Improvements in electric alarm apparatus for doors, windows and the like.

11,716. C. PARKES. The "preventum" crank and wire and electric pull-out bell pull.

11,717. THE SAFETY TREAD SYNDICATE (LIMITED), JOSEPH MASON and JONATHAN MASON. London. Improvements in coal plates, covers for cellars, electric light boxes and like purposes.

11,728. E. F. MOY. London. Improvements in switches for electric currents.

11,729. P. REINER. London. Improvements in coin freed machines for administering electric currents.*

11,749. A. B. WOAKES. London. Improvements in heating liquids by electricity.

June 15, 1893.

11,759. C. TURNBULL, JUNIOR. Newcastle-on-Tyne. Improvements in or relating to electric bells.

11,801. C. N. RUSSELL. London. Improved means and appliances connected with securing electric light fittings.

11,819. E. H. ALLEN. London. Improvements in electric railway trolleys. (Date applied for under Patents Act, 1883, Sec. 103, November 16, 1892, being date of application in United States.)*

June 16, 1893.

11,842. E. PAYNE. Cuckfield. Improvements connected with the insulation of electrical conductors.

11,890. P. RABBIDGE. London. Improvements relating to telephones.

June 17, 1893.

11,921. W. H. JOHNSON. Southampton. Improvements in and relating to suspensory apparatus designed more especially for electric and other hanging lamps, but adapted for suspending and regulating the height of suspension of other articles.

11,973. SIEMENS BROS. AND CO. (LIMITED) and E. F. A. OBACH. London. Improvements in apparatus for electrolysis of water.

11,977. J. O. COWPER. Coles. Improvements in electrical search and signalling apparatus.

11,983. D. G. FITZGERALD. London. Contact plates or electrodes for forming and charging, or for alternately charging and discharging plates or elements to be used in voltaic batteries.

June 19, 1893.

12,006. J. STRONG. London. Strongs' arc-lamp.

12,011. R. BROWN. Preston. Electric low-water alarm for steam boilers.

12,032. EASTON AND ANDERSON (LIMITED), and E. W. ANDERSON. Improvements in electric travelling cranes or hoists.

June 20, 1893.

12,070. C. RICHARDSON and E. G. HERBERT. Manchester. Improvements in switches for controlling electric currents.

12,139. M. HUIIN and M. LE BLANC. London. Improvements in electric machines and transformers.

12,141. E. TYER. London. Improvements in electrical time switches for signalling.

12,142. E. TYER. London. A safety switch for electrical lock and block apparatus on railways.

12,143. E. TYER. London. Electrical apparatus worked by passage of a railway train or vehicle.

12,153 A. G. WATERHOUSE. London. Improvements relating to methods of measuring, controlling, and regulating electric currents, and to apparatus therefor.

June 21, 1893.

12,191. W. H. INGALL. Birmingham. An improved globe or shade holder for electric gas or other lamps.

12,196. Sir C. S. FORBES, Bart. Improvements in the arrangement of telephone circuits, and switching devices therefor.

12,233. J. GOTT. London. Improvements in controlling, adjusting, and mounting movable coils in telegraph recording instruments. (Charles Cuttriss, United States.)

12,242. J. E. SENECHAL. London. An improved electric lighting device.

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June 22, 1893.

12,219. A. D. Ash. Willenhall, Staffs. Certain improvements in electrical switches.

12,257. G. Binswanger and H. J. Coates. London. Improvements in electricity meters.

12,291. A. J. Boult. London. Improvements in secondary batteries. (Henry Woodward, Canada.)*

12,314. G. C. Fricker. London. Improvements in electrically illuminated signs.

June 23, 1893.

12,362. M. F. Armstrong, J. Kincaid, J. E. Waller, and E. Manville. London. Apraratus for the marking of meat by electricity, and other analogous purposes.

12.374. H. C. Gover. London. Improvements in portable electric lamps and batteries therefor.

June 21, 1893.

12,437. P. Rosling and F. I. A. Matthews. Leeds. A mode of, and means for, electrically controlling lubricators.

12,444. J. Bradford and J. P. Williams. London. Improvements relating to electric railway signals.

12,457. D. Urquhart and J. M. Small. London. Improvements in junction boxes for underground electrical conductors.*

12,455. M. Hutin and M. Le Blanc. London. Improvements in alternating current electric machines.

June 26, 1893.

12,490. E. S. and Eva S. D'Odiardi. London. Improvements in the means of conveying or administering electricity for medical purposes or others.

12,491. E. S. and Eva S. D'Odiardi. London. Improvements for administering electricity to animals or human beings.

12,492. E. S. and Eva S. D'Odiardi. London. Improvements in liquid electrodes.

12,493. E. S. and Eva S. D'Odiardi. London. Improvements for charging vapours for inhaling purposes or others with electricity.

12,507. E. Vogt. London. Improvements in the construction of galvanic cells.

12,514. E. Rochester. London. Improvements in safety fenders or life-guards for electric street railway carriage and other vehicles.*

12,516. A. Graham. London. An improved loud-speaking telephone and circuits for same.

12,523. C. J. Wollaston. London. Improvements in, or connected with, brushes or other appliances for the curative application of electricity.

June 27, 1893.

12,577. J. A. K. McGregor. London. Underground electric system.

12,612 E and N. Priddle and Co. (Limited). Improvements in the construction of electric fittings.

12,625 W. Walker. London. Improvements in, and connected with, the purification of sewage by elctrolysis producing electricity as a bye product.*

June 28, 1893.

12,662. E. Andreoli. London. Improvements in electrolysis.*

12,702. G. G. M. Hardingham. London. Improvements in electric cables (the firm of Felten and Guilleaume, Germany).

June 29, 1893.

12,785. A. G. New and A. J. Mayne. London. Improvements in switches for electric currents.

12,786. A. G. New and A. J. Mayne. London. Improvements in self-regulating mechanisms for electric arc lamps.

12,787. J. L. Dobell, C. T. Shrewsbury, F. L. Marshall, and J. Cooper. London. Improvements in the manufacture of coke or carbon for electrical purposes.

June 30, 1893.

12,806. F. A. Thum. London. Improvements in electrical switches.*

12,850. F. A. Brocq. London. A counter of electricity.

12,852. W. Lowrie. London. Improvements in or relating to the distribution and supply of energy in electric current circuits.

12,857. J. C. Richardson. London. Improvements in and connected with tanks for the electrical decomposition of chloride of sodium or potassium in solution.

12,864. J. F. W. Featherstonhaugh. Improvements in electric locomotives and vehicles.

12,866. R. W. Barker. London. An improved electric lighter.

12,872. J. Perry. London. Improvements in mechanisms for electrically operating clocks.

June 3, 1893.

12,971. O. Dahl and S. L. Phillips. London. Improvements in alternating-current motors. (Date applied for under Patents, &c., Act 1883, Sec. 103, December 8, 1892, being date of application in United States.)*

12,981. I. A. Timmis. London. Improvements in signal telegraph or other posts.

July 1, 1893.

12,919. W. Jeffrey. London. Electrical arc lamps.

July 4, 1893.

13,024. G. C. James. Sheffield. Improvements in instruments for measuring and indicating electrical energy and for other measurements.

13,064. S. P. Thompson. London. Improvements in devices for prevention of retardation in electric cables.

13,066. A. J. Boult. London. Improvements in or relating to the manufacture of incandescent mantles or filaments for use in connection with gas or electric incandescent lamps. (Otto Hermann Steuer, Germany.)*

13,081. J. Pitkin. London. Improvements in the construction of plates for secondary batteries.

July 6, 1895.

13,203. D. Cook. London. Improvements in electric traction and apparatus therefor.

13,217. The Lithanode and General Electric Company (Limited) and J. T. Niblett. London. Improvements in secondary electric batteries.

July 5, 1893.

13,101. D. Urquhart. London. Improvements in the method of winding for dynamo motors for balancing a three-wire system of electrical distribution.

13,111. J. Pease. Apperley Bridge, Yorkshire. Improved traverse motion of the commutator and armatures of dynamos and electric motors.

13,133. J. H. McLean. London. An improved automatic electro-magnet switch.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

9,108. Shrewsbury and Dobell. Electric batteries.

10,999. Webber. Electric clocks.

11,194. Drake and Gorham. High-tension circuits.

11,822. Aron. Driving clocks, &c., electrically.

12,999. Kapp. Distributing electric currents.

13,381. Bright and Mercier. Electrical storage plates.

13,473. Binswanger. Heating and Cooking by electricity.

13,542. Elmore, F. E. and A. S. Cells for electrolysis, &c.

13,678. Webb. Electric bell push and pull.

13,718. Doulton and Morris. Electric conduits.

13,765. Hutin and Leblanc. Electro-dynamic machines.

14,160. Grimston. Electrically working the gear of guns.

14,250. Rosenthal and Doubleday. Secondary batteries.

14,360. Davis. Electric bell.

14,647. Siemens Bros. and Co. (Limited) (Siemens and Halske). Electromotors.

14,674. Marr. Electric telephonic apparatus.

15,170 Hoffmann. Electro-magnetic alarm apparatus.

16,545. Ball. Galvanic batteries.

23,057. King and Mendham. Electric light ceiling roses.

1893.

4,368. Ward. Electric arc lamps.

6,559. Dewey. Electric heating apparatus.

6,885. Lake (Cattori). Electric railways.

7,389. Thomson (Coffin). Electrically-welding metals.

8,257. Irish. Circuit breakers.

8,808. Lehmann. Electric accumulators.

9,552. Partzold. Microphones and telephones.

9,818. Cummings. Electrical conductors.

9,828. Martin. Non-conducting coverings.

COMPANIES' MEETINGS AND REPORTS.

Eastern Telegraph Company (Limited).

The forty-second half-yearly General Meeting of this Company was held on Thursday, July 13th, at Winchester House, Old Broad-street, London, E.C., under the presidency of Sir John Pender, G.C.M.G., M.P.

The SECRETARY (Mr. George Draper) having read the notice convening the meeting and the minutes of the last meeting, which were confirmed,

The CHAIRMAN said: Gentlemen—You have had the report in your hands for some time, and I presume that you will, as usual, take it as read. Before I ask you to approve the report I will, as usual, go into some of the details, so that you may have the fullest information that it is in our power to give as to the working of the Company during the last six months. The gross revenue for the half-year under review amounted to £372,852 as against £382,207, or a decrease of £9,355. Analysing the receipts from various sources, we find an increase of about £3,000 in the message receipts. There is a reduction in the traffic with several places, esp ecially South America and Portugal, but this is more than recouped by the increase in other directions, notably South Africa, Egypt, Turkey, India, and beyond. The reduction in the gross revenue is due to our having received £17,700 from our investment in the shares of the Eastern and South African Telegraph Company as against £29,500 in the corresponding period, or a decrease of £11.800. I may explain to you, again, regarding this investment in the Eastern and South African Company, that

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that Company is practically an arm of this Company, but for many reasons which I need not explain to-day, on account of our concessions and for other reasons, it is necessary for us to work the two Companies separately. The large bulk of the shares, however, is held by this Company. That Company, instead of paying 10 per cent. this last year, paid only 8 per cent., but there were reasons for making the reduction. There was the sort of shadow that had overcome the African traffic, and altogether the reasons were such that the Eastern and South African Company thought it was more prudent to pay 8 per cent. instead of 10 per cent. Still, notwithstanding that reduction, I think I shall be able to show you, before I finish my remarks, that this Company stands to-day in probably a better position than it has ever before been my pleasure to report to you.

That, however, is a statement a little in anticipation. You will get the facts more as I go on with my remarks. The total ordinary expenses for the half-year ended March 31, 1893, amounted to £102,499 as against £105,820, or a decrease of £3,321. The details are as following:—General expenses in London £9,369 as against £9,589, or a decrease of £220. Working expenses at stations £79,926 as against £78,695, or an increase of £1,231. Several of the items under this head show substantial decreases. The principal increase is in the salaries and wages of our staff at stations, there being an increase of thirty clerks compared with the corresponding period of last year. There is also to be taken into account the operation of the scheme adopted some years ago to provide a regular scale of promotions for the younger men as they qualify themselves by accuracy and speed in working, as well as by general good conduct and intelligent progress. You can quite understand that a staff cannot remain in the same position from year to year. As our business progresses we not only have to add many additional clerks but the younger clerks become older, and have to be considered in connection with the question of promotion. You cannot effect promotion generally without putting your hand into your pocket; but still, all these things are in keeping with the general growth of the Company, and as the Company improves generally, which it is doing, the clerks are naturally entitled to some consideration. The following accounts show reductions: Special repairs to buildings at stations, £1,974; and negotiations with foreign Governments, £1,375. Other telegraph companies hiring our ships have been charged a proportion of the depreciation for the period the ships were on their work. We have, therefore, for the half-year under review, a charge of only £2,245 against revenue account for maintenance ships' fund, against £4,000 in the corresponding period of last year. Our ships have been employed in doing a great deal of work outside our own system, and that reduces the general costs under this heading. The expenses attending repairs and renewals of cables amounted to £32,533 as against £53,515, or a decrease of £20,982. It will be seen from abstract C at page 6 that we have received during the half-year over £26,000 for the hire of our ships for cable-repairing purposes. That tells in two ways. The earnings of the ships bring money into our exchequer; and, moreover, if these ships had been employed in repairing our own cables it would represent a double loss, as you can quite understand. There is no position which the ships occupy so satisfactory to the Company as when they are doing nothing in regard to our own cables, but we have found out lately that while they are doing nothing for us we can obtain employment for them in doing work for other people. We have got paid in that way, and we also save the expenses of maintenance ships in a very handsome manner. In these times £26,000 is a large sum of money, and probably there are many shipowners now who would look on that amount as a very nice return on a larger number of ships than we have at our disposal. I may tell you that we keep our fleet fully manned and in a thorough state of efficiency, ready for repairs at short notice. Sometimes they are fully occupied on our own work, but when we can spare them for repairs to the cables of other companies it tends, as I have already said, materially to keep down the cost of our own repairs, as is amply demonstrated this half-year. After providing the usual amounts for interest on debentures, debenture stock, and Preference shares, we are able to propose the usual final dividend of 1¼ per cent., and a bonus of 1½ per cent., making with the interim dividends already paid, a total distribution of 6½ per cent. for the year ended March 31, 1893, and to carry the sum of £88,000 to the reserve fund, against £68,000 in the corresponding period of last year.

I think that justifies the remark that I made earlier in regard to our position to-day. Last half-year when I was addressing you I said that I believed I was putting before you the best account we had ever presented you with since the beginning of the Company, but I think we have improved materially upon last half-year. I only regret that this improvement, more or less, arises out of a great many of the disasters that we have been hearing about. We find that our Company and telegraph companies generally, and submarine telegraphs in particular, are so much used now for commercial purposes in every part of the world that when good times exist we get a very fair share of the traffic, and that when bad times come we are employed in order that those bad times may be brought to an end as quickly as possible. We have seen lately certain banks going down like so many ninepins, whose businesses have to be reconstructed. All these circumstances tell to the benefit of the submarine telegraph system, and give us now a more satisfactory view of it as being a stable investment than at any period probably of our history. We are very young yet, scarcely 25 years old, but still we are now holding a position among the companies of this great City of London second to none. During all these hard times the value of our shares has been maintained on the Stock Exchange, and we have deserved to maintain the value of this property, because we have given very strong evidence of its satisfactory position and its increasing prosperity. Every year and every half-year we are learning something. Like electricity itself, which may be said to be in its infancy, we have attained very strong manhood in a very limited number of years. When the Company arrives at a good age I hope its position will be still better than it is to-day. It is probably at the head of all institutions of the kind, and all of us who are connected with it ought to be proud of the position that it occupies. A circumstance occurred the other day in connection with which we took a course which I am sure the shareholders will approve. When war has occurred in previous years we have always tried to help those who could not help themselves; we have always endeavoured to ameliorate the condition of wounded soldiers and sailors, and we have received letters of gratitude from time to time from the parents and relatives of these people which are very touching indeed. When the "Victoria" disaster occurred the other day we found that there were many in this country who were deeply anxious as to the fate of their relatives or friends on board, and who desired to know who had been saved from that terrible disaster. I therefore wrote at once to Admiral Hoskins, saying that whatever he or the Admiral at Malta thought ought to pass over our lines free for these poor people—and for officers also—the Company would be glad to accept (hear, hear). As you are aware, the Company was publicly thanked in the House of Lords by Earl Spencer, and I am quite sure that you will to-day endorse our action, which brought comfort to some homes, though, unhappily, sorrow to others.

I will now continue my remarks regarding the financial position of the Company. We have applied a further sum of £54,077 from reserve fund in reduction of the cost of the Aden-Bombay No. 3 cable and other capital expenditure, so that our capital expenditure, with the exception of some small additions to our land and buildings, remains at the same figure as last year. The total amount applied out of the reserve fund from time to time now reaches the substantial sum of £1,256,822. That, gentlemen, amounts to this, that we have practically duplicated, and in some cases triplicated, our system without increasing our capital. You can all understand the benefit of keeping down the capital. By doing so we secure for you in every way something like a permanent income. We cannot stand still as a Company, as I shall show you as I go on. I think at the last meeting I mentioned to you that we had entered into an arrangement with the Government for laying a cable from Zanzibar to Seychelles and Mauritius. After considerable delays the negotiations were concluded, and the documents are all signed; and I believe that before the end of the year we shall have completed that important additional link in our very important chain of submarine cables. I may state that in regard to this concession which I have just mentioned, several other parties applied for it, but none of them were in the position that we are in. We have so built ourselves in around there, with our system extending all over the world, that we occupy such a position that no one can compete effectually with us. The time we devoted to this work was very considerable, and the consequence was that, after due consideration, the Government entered into this arrangement with us. They did so with their usual keenness, and harder men at driving a bargain I have never come in contact with. Still, when a bargain is made they stick to it. The line is largely strategical as well as commercial. As I said at the time, it is absolutely necessary to lay a line to Mauritius to connect her by our system with India and other parts of the world. Competition is active there as elsewhere, between cane sugar and beet sugar, but cane sugar will always beat the other if there are only proper facilities given to it. I hope, therefore, that this new line will greatly benefit Mauritius, and that it will also contribute in maintaining that *esprit de corps* which makes Englishmen at the head of the commercial world.

We had another interesting "battle," as I may call it. We had practically secured a concession from Portugal to lay a cable for connecting the Islands of the Azores with Lisbon. We went into that matter for the reason that one of the conditions was that the privileges we had enjoyed at Lisbon would be extended for another ten years if this cable were laid. In doing this work we are associated with other companies, but we obtained a very great advantage also for the Eastern Company. The contract has been signed by the Minister subject to the approval of the Cortes, which there was every reason to believe would confirm it, when a French company came in with the support of the French Government on so-called political grounds, which, in our opinion, the enterprise did not involve. Let me tell you that the French Government do not hesitate to say and do straight things in support of their people, whereas our Government does not do so, but leaves us to fight our own battles. The result in this case was that for the moment the French succeeded in taking away the concession from us. But the French company having failed to carry out the work within the term of one year fixed by the concession, we were invited last May by the Portuguese Government to resume the negotiations which finally culminated in the contract being definitely granted and signed on June 17th.

I have given you a great deal of information to-day, but I have not done yet, although I have finished the financial part of my information. I have now, however, to refer to the death of our late Managing Director. I believe there are many shareholders present who during the last quarter of a century have seen Sir James Anderson occupying his place here from six months to six months. He was a trusted and valued colleague, and I am sure I can say, working with him as I did for nearly 25 years, that he was always ready and always willing to promote the welfare of this Company, which it was his ambition to see take the very high position it has attained to. We, therefore, very greatly regret the death of our valued and honoured colleague, and I am quite sure that you will join in this expression. I have now referred to almost everything excepting the last point that I have to bring before you, namely, the appointment of my son, Mr. J. Denison Pender, to the position which Sir James Anderson occupied. My son is young, but he has been trained for this work, to which he has served a good long apprenticeship. Very few men know more about boats or about the work generally on which he is now engaged. I may say that the suggestion that my son should take this position did not come from me so much as from other members of the Board. They thought he was a competent man, and the proper man for the place. In speaking to my son on this matter I said to him: "You know this work. I could not put my finger on a man who would do it better than you can, but you

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must make up your mind in entering upon it that you must do so with an earnestness of purpose and continue the work which your father and older men connected with it have carried on. You must take up the work with vigour and energy, and success will only be attained by you by devotion to the work you are asked to undertake." I may tell you, gentlemen, that this appointment was not made in order to place my son in this position, because he is perfectly independent of any such position; but he loves work, he knows the work that has to be done, he is proud of the position which the Company holds, and he has accepted the appointment with the determination to carry out the work as it has always been carried out—with vigour, energy, and economy. I now beg to move the following resolution:—

"*That the printed report and accounts of the Directors to March* 31, 1893, *submitted to this meeting, be and the same are hereby received and adopted; that a dividend on the Preference shares of the Company to June* 30, 1893, *at the rate of* 6 *per cent. per annum, be paid, less income-tax; and that in accordance with the Directors' recommendation, a dividend be and is now declared of* 2*s.* 6*d. per share, with a bonus of* 3*s. per share, both free of income tax, on the Ordinary shares of the Company, making, with previous payments by way of dividend on account, a total payment of* 6½ *per cent. on those shares for the year ended March* 31, 1893."

The VICE-CHAIRMAN (The Marquis of Tweeddale): I beg to second that.

The CHAIRMAN: If any gentleman desires to put any questions to me I shall only be too ready to answer them to the best of my ability.

Mr. W. GOODSALL: I read in one of the papers this season a report stating that Sir John Pender was enjoying a well-earned holiday in the Levant with a party of noble friends. I should like to ask whether the vessel, the "Mirror," was Sir John's own yacht, as stated, or whether it was one of the vessels of the Company? If the latter, I should like to know what the cost of the little trip was. I understand that Sir John Pender's son has been appointed Managing Director of the Company; and he is also, I believe, a Director of the Telegraph Construction and Maintenance Company. (No, no.) He is not? (No.) Then I will not say anything more on that point. As long as you say that I do not wish to say anything further.

Mr. BAINES: Before you reply to Mr. Goodsall I should like to make one or two remarks regarding the very stationary character of the dividend. I listened with great pleasure to what the Chairman said, and he congratulated us on our position at the present time. I am sorry to disturb the harmony of his remarks, but it seems to me that as we are doing so extremely well, the interests of the shareholders might be a little better cared for. This Company has a very ample capital and is conferring great benefit on the commercial world as well as on the community generally: and I think that a Company like this ought to pay a better dividend, especially considering the risky character of our property. Banks pay 8 per cent. or 10 per cent., but we do not seem to be able to get beyond 6½ per cent. At the inception of our Company the prospect of very large dividends was held out, but certain circumstances arose with which the shareholders are familiar, and we were disappointed by the code system. Still, I think it is the duty of the Directors to see if they cannot make up to us for that. The shareholders will notice also that every half-year large sums are carried to the reserve fund; in this past half-year alone, £88,000. No one can appreciate more than I do the value of a reserve fund. It is a very valuable asset, and strengthens our position in the share market, and enables us also to carry out projects which we could not otherwise do. But there is a limit to a reserve fund, I should say, and I think that some portion of this amount which is carried to reserve fund might be distributed among the shareholders, especially when we come to consider that the duplication of our cables, and not only that, but the laying of fresh cables, have been provided in a great measure out of revenue. I may be wrong, and I do not profess to be an adept in accounts, but it seems to me that when these large sums that have been earned by our original capital are diverted to these purposes some part of it belongs to us, and I think that the Directors should consider the propriety of giving to the shareholders a part of it *pro rata* to their holdings. This may be worthy of their attention. I think that the accounts want thoroughly overhauling, because I believe that economies might be effected if they were kept thoroughly well in hand. I have been a shareholder for many years, and some years ago I mentioned the circumstance of the electrician's retaining fee, which I believe was at that time about £150 every half-year, or £300 a year. The Directors looked into the matter, and found that they could cut this item down considerably, and they did so, and it now appears as £75. That was a step in the right direction. The gentleman behind me has referred to the appointment of Mr. Denison Pender. I have nothing much to say on that point, although I was going to ask if his qualifications fitted him for such a very important office. The Chairman says that they do, and under those circumstances I can say nothing further about it. With respect to these trips which Sir John Pender tells us every now and then he takes, he says that the different *employés* like to be called upon, and that the trips afford an opportunity of seeing the condition of our property. I have had some information conveyed to me, however, and I wish to ask whether it is the case that the "Mirror" goes into Marseilles or Malta, and is dismantled and then fitted up in a luxurious style, with an installation of electricity. It then goes into some port in the Mediterranean, where it quite astonishes people. That is what I hear, and I have no doubt it does do so. I do not object to these trips, but I think that more attention might be given to the interests of the shareholders.

Mr. JOHN NEWTON: I should like to say a few words with respect to the question of dividend and the position of the Company. I claim that this is not a risky property. The experience of 20 years which we have had proves that it is a very substantial and safe property, and as certain a one as you can put your money into. The market confirms that for no class of security stands so well as telegraph property at the present time. As regards the dividend, the gentleman who has just spoken on that matter has been a shareholder with me for more than 20 years. In former years we used strongly to criticise the Directors. I am very glad to see him continue that *rôle*, because it will not do the Directors harm or the Company either; but I take a different view. I am perfectly satisfied that this Company is doing as well as it can for its shareholders. My experience of former days was that we were not satisfied with 6½ per cent., because we had been promised 15 per cent. and 20 per cent. in the prospectus; but times change. There is, however, a point which all shareholders in telegraph property must not forget, and it is one that has troubled me much, namely, that as soon as you begin to advance your dividend beyond 6½ per cent. and go to 7 per cent., you will have the Conference after you, and have to take a reduced dividend. It is much better to spend your revenue in consolidating your property and increasing its strength, and commanding influence, than getting it in an increase of dividend. You get the benefit by the higher market value of your property when you wish to sell, or your children will get the benefit. If you doubt that try and buy 1,000 shares in the Eastern Telegraph Company at the price they are now quoted at, and you will find that you will have to pay much more. The reserve fund investments are as decided a testimony as you can have of the capacity of this Board. Look at the thousands and millions, you may say, that have been lost; but you have had money invested by this Company which is still intact, notwithstanding the disasters that have taken place. I say that there is no Board more entitled to the confidence of their shareholders than the Board of this Company. It is in the knowledge of that fact that I have taken the part which I have taken in recent years. I do not think that anyone who has put money into this Company has failed to make a profit, or he stands to make a profit. As regards the question that has been raised concerning the Chairman's trips, I must say that in my opinion it is perfectly right that someone should go and represent the Eastern Telegraph Company in the world beyond England. Whom could you select if you did not like the Chairman to go? (A voice: "You.") The Chairman is the proper man to go. I should be very pleased to go, but I should not represent the Company if I did. Someone, however, ought to go. Put the matter on a lower ground. What man would not do such a thing as this by way of advertisement if he possibly could? Thousands of pounds are spent in advertising in order to get at the position to which our Company has attained to-day. It is therefore simply ridiculous to grumble about the trips of the Chairman, because if he did not make them someone must, and no one could make them so well. With reference to the appointment of Sir John Pender's son, I know that someone has said that it is nepotism, but in great companies like this you must have young men who are capable. It is all very well having men who are advanced in years, but you have got enough of them on the Board now; and Mr. Denison Pender has been trained to the work, no doubt. If he has not, he ought to have been. If I had had a father in his position, I know that I should have known something about the work (laughter). With a company doing such work as this, and standing in such a position as it does, there ought not to be anything in the nature of criticism unless there is reason for it.

Mr. BAINES: I should like to add a few words to what I said before. I forgot to say then that I desire to tender an expression of my regret at the death of Sir James Anderson. I may say with regard to what the last speaker has said about the dividend and the Conference coming down on us if you increase it, you can issue additional shares *pro rata*, so that the shareholders might receive some benefit.

The CHAIRMAN: There is nothing I enjoy so much as a little criticism; but there is nothing that astonishes me so much as that the criticism should come from the quarters where it has emanated from to-day. I am not going to say a disrespectful word of any gentleman; but I will say this—that the larger interests involved in the Company have all been complimentary to us, and not in any way adverse. When I go back to the time more particularly that our friend referred to, when he first became a strong critic of the Board, and when we see the contrast between those days and these, I think he might have had the nobility of character to say that he was disappointed in his early days, but that we had made this the great concern we thought we should make it; and that he was wrong then, and would now come to help us. Instead of that, he comes here to try and depreciate what you all acknowledge to be a great success—a marked success of the times. You can therefore well understand that I look upon his criticism as being rather complimentary than otherwise. Two gentlemen have referred to the trips which I occasionally take. I wish I could take them oftener. My time, however, is too valuable to enable me to go, but I think if I were to come to the Company and say that you ought to pay me a considerable sum for every trip I take, it would be to your interest to make the payment. I charge the Company nothing for the time I expend in their interest beyond the regular remuneration which I receive as a Director. I go on these trips from time to time, and I do great and good work for the benefit of this Company. This very contract for the Azores cable which I have brought before you to-day was absolutely, I believe, the result of my visit to Portugal. They paid me there the highest compliment they could by conferring upon me the highest honour which the Portuguese Government can give to a private individual; and is that not a compliment to this Company, and is it not to the benefit of the shareholders of the Company? Do not suppose that I go out on these trips merely for pleasure. I never lose sight of the interest of this Company. I have been to Turkey, and you know what good I did there for you; and I have been to Portugal and to Athens, and those visits were also beneficial to you. We have had great difficulties with France, but still, when I went there they presented me, as your Chairman, with the Order of the Legion of Honour, which is an honour they rarely confer upon anyone out of their own country. I mention these things not in an egotistical manner, but in order to let you see that the countries of the world

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appreciate the work we are doing. I say it is a very small thing for any member of this great Company to come here and try and depreciate those who are doing so much both to maintain and to exalt the position of the Company. The object of every act of mine in connection with this Company is intended for the benefit of its shareholders.

Mr. BAINES: I said distinctly that I did not object to your trips.

The CHAIRMAN: I am not referring to any one in particular, but to those who try to lower the dignity and standing of this Company. Mr. Newton has for many years watched the progress of this Company. I have always acknowledged his criticism as being fair and just. He knows pretty well what we are doing, and is shrewd enough to tell us when we are not going in the right direction. He has made remarks to-day which I ask the shareholders to remember. If the management of this Company had not been in the hands of thoughtful, prudent, and cautious men, you would not be occupying the position you do to-day. It is with companies as with men. If you want to be strong in social life, in political life, or in any position in life where wealth is more or less respected as a great power, you must fortify yourself in that direction. I say that if we had not laid down the policy and carried it out strictly of having a large reserve fund, you would not be in your present position. We have done more than that, for we have practically duplicated, and in some cases triplicated, the system without materially increasing the capital. What more do you want than that? I think I have now said enough to satisfy you that if we saw that it was prudent, and that the time had come when we could increase your dividend, the Directors would be only too glad to do it; but, still, we are increasing the value of your stocks, as you must admit, and you cannot have your cake and eat it too. Although we are not giving an extra 1 per cent., we are adding to the value of your property considerably, and that is the way you ought to look at the matter. When the time comes, and we have completed our work—we have still two big jobs to do—and when money comes in more freely than we can see our way to invest it, you may depend upon it that the shareholders will have our first consideration.

Mr. BAINES: That is what I wanted to know.

The CHAIRMAN: I think I have now said all that I had to say, and I will therefore submit the resolution. Those who are in favour of it will please hold up their hands; on the contrary; it is carried unanimously. That finishes the business of the meeting. If I have spoken a little warmly ("no, no") you may depend upon it that I have spoken in your interests. I am proud of this position, and I do get a little warm sometimes when I find that it is in any way assailed. I do not mean to say that you (to Mr. Baines) assailed us, or went very far out of the way, but still you did a little (laughter).

Mr. BAINES: I did not catch what you said, but we have had tussles before. You have had struggles with me before, and so have I with you. We both hit from the shoulder, but we are none the worse friends for that, I hope. I propose a vote of thanks to the Chairman, Directors, and staff, and I think we may congratulate ourselves on having such a Chairman and such Directors. At the same time I think a little criticism does good, and I do not think that Sir John Pender need feel very angry with me.

Mr. NEWTON: I will second that. I wish also to make good an omission in my former remarks, as Mr. Baines did, by regretting the great loss which the Company has sustained by the death of Sir James Anderson. I wish to join in the expression of sympathy which you have given utterance to in regard to that matter. I hope that Mr. Denison Pender will follow in Sir James Anderson's footsteps, and be as capable and successful in our affairs as our late Managing Director was.

The resolution was carried unanimously.

The CHAIRMAN: I beg to thank you very warmly for this vote, and I thank Mr. Baines also for the pleasant way in which he has brought this meeting to an end. There is nothing I like so much, I say it again, as to be able to hit out when I am hit at; but you may depend upon this, that these little episodes in our business show pretty well that there is good back in it. When I see so many gentlemen here who sympathise with, and approve of, the remarks I have made I do not regret what has happened. It has always been the desire of this Board to be in constant and friendly touch with our shareholders, and to have nothing in the background. We put everything before you regarding our affairs. If we do anything wrong we expect to be pulled up; but if we do everything that is right, and bring matters to a successful termination, we expect to be a little complimented by you.

The proceedings then terminated.

Anglo-American Telegraph Company (Limited).

The following is the report of the Directors, to be presented to the ordinary general half-yearly meeting of the proprietors, to be held at Winchester House, London, on Friday next, the 28th inst., at 2 p.m.

The total receipts from January 1 to June 30, 1893, including the balance of £737. 3s. 9d. brought forward from the last account, amounted to £148,185. 14s. 11d. This sum, however, is subject to revision, as the lawsuit between this Company and the Paris and New York Telegraph Company is still pending before the Court of Appeal in Paris, and will not be heard until after the vacation. The traffic receipts show an increase of £367, as compared with the corresponding period of last year.

The total expenses of the half-year, including the repair of cables, &c., as shown by the revenue account, amounted to £60,182. 13s. 2d., being an increase of £813. 11s. 4d. upon the corresponding period of 1892.

One quarterly interim dividend of 12s. 6d. per cent. on the Ordinary stock and of £1. 5s. per cent. on the Preferred stock, was paid on May 1, 1893, absorbing £43,750, and a second quarterly dividend at the same rates will be paid on August 1, 1893, leaving a balance of £503. 1s. 9d. to be carried forward to the next account.

The Company's repairing ss. "Minia" has been engaged during the past half-year in the following repairs, viz.:—Heart's Content and Placentia (Island Cove) cable, Placentia and Sydney (Southern) cable, St. Pierre and Duxbury cable, Brest and St. Pierre (1869) cable. Three breaks have occurred in the last-mentioned cable in deep water, one of which was repaired on June 10th, and the "Minia" is now employed in the repair of the other. The Valentia and Heart's Content cable, laid in 1874, was broken on July 9th 575 miles from Heart's Content; the Telegraph Construction and Maintenance Company's ss. "Calabria" has been chartered for the repair. The Company's other cables and land lines are in good working order and condition.

The Directors report with extreme regret the death of their late esteemed colleague, Sir James Anderson, which occurred on May 7th last, and at the same time desire to record and acknowledge the valuable services he rendered to the Company, not only at the time the Atlantic cables of 1865 and 1866 were laid, but during the many years he occupied a seat at this Board.

Direct United States Cable Company (Limited).

The following is the report of the Directors for the six months ended June 30th, to be presented at the thirty-second ordinary general meeting to be held at Room 174, Winchester House, Old Broad-street, on Friday next, the 28th inst., at 1 p.m.:—

The half-year's revenue, for the half-year ended June 30th, after deducting out-payments, amounted to £40,836. 17s. 4d., as compared with £39,014. 14s. 1d. for the corresponding period of 1892, being a difference of £1,822. 3s. 3d. in favour of the half-year under review. The working and other expenses for the same period, including income-tax, amounted to £18,898. 5s. 7d., leaving a balance of £21,938. 11s. 9d. as the net profit of the half-year, making with £3,129. 0s. 7d. brought forward from the previous half-year a total of £25,067. 12s. 4d. For the corresponding period 1892, the working expenses and other payments amounted to £19,013. 13s. 3d. Three quarterly interim dividends of 3s. 6d. each per share, amounting to £31,872. 15s., have been declared and paid during the financial year, and a final payment of 3s. 6d. per share is now proposed, making, with three interim dividends, 3½ per cent. for the year, being a total distribution of £42,497. After transferring £3.000 to the reserve fund, which now stands at £267,415. 12s. 7d., the balance of £819. 2s. 9d. on the revenue account is proposed to be carried forward.

The new permanent structures at Ballinskelligs, consisting of a new station building and a house for the superintendent, are now completed and occupied. Two blocks of semi-detached cottages are needed at the station to replace the dilapidated wooden houses at present occupied by the married staff, and will be provided at an estimated cost of about £2,700. A new station for the acceptance and delivery of telegrams has been opened at 142A, Winchester House, Old Broad-street, E.C.

Pursuant to the provisions of the Articles of Association, two of the Directors, viz., Charles Meara, Esq., and E. M. Underdown, Esq., QC., retire by rotation, and being eligible offer themselves for re-election. Mr. John G. Griffiths, F.C.A., and Mr. John Sawyer, F.C.A., the auditors, retire pursuant to the Articles of Association, and offer themselves for re-election.

Globe Telegraph and Trust Company (Limited).

The following is the report of the Directors of this Company, to be presented to the twentieth ordinary general meeting, to be held on the 27th inst., at Winchester House, E.C., at one o'clock.

The net revenue of the Company for the year, after deduction of expenses, amounts to £188,931. 10s. 8d., and makes, with the balance £938. 4s. 1d. brought forward, a total of £189,869. 14s. 9d. From this amount there has been distributed the sum of £126.300. 16s. 8d. in interim dividends, leaving an available balance of £63,568. 18s. 1d.

The Directors recommend the payment of a final dividend for the year of 3s. per share on the Preference shares, and of 4s. per share on the Ordinary shares, making, with the previous distributions, a total dividend for the year of 6 per cent., less income-tax, upon the Preference, and 4 per cent. net (against 4⅞ per cent. for the preceding year) upon the Ordinary shares, and carrying forward a balance of £1,304. 17s. 9d.

The Directors report with much regret the death on May 7th last of Sir James Anderson, their valued and much esteemed colleague, who had been a Director of this Company from the date of its incorporation. The Hon. W. St. John F. Brodrick, M.P., a Director of the Brazilian Submarine Telegraph Company (Limited) has been elected to fill the vacancy.

Mr. Sidney Collett has been appointed secretary in place of the late Mr. William Payton, whose decease was announced in the last report. Since the last meeting a Staff Endowment Assurance Scheme has been carried into effect, the Company's contribution being about £100 per annum. In conformity with the Articles of Association, Sir Henry Daniel Gooch, Bart., and James Pender, Esq., two of the Directors, retire, and being eligible offer themselves for re-election. The auditors, Mr. John George Griffiths, F.C.A. (Messrs. Deloitte, Dever, Griffiths, and Co.), and Mr. William Griffith, B.A., barrister-at-law, also retire; and Messrs. Deloitte, Dever, Griffiths, and Co., and Mr. Griffith offer themselves for election.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—Notice is given that the coupons on this Company's Five per Cent. Debentures (1884 issue), due for payment 31st inst., will be paid on and after that date at Parr's Banking Company and the Alliance Bank (Limited), Bartholomew-lane, London, E.C. The coupons should be left at the bank three days for examination.

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Electric Construction Company (Limited).

An extraordinary general meeting of this Company was held at the Cannon-street Hotel yesterday (Thursday) for the purpose of confirming as special resolutions the resolutions passed at an extraordinary general meeting held on July 5th (which were given in *The Electrician* of June 30th, page 248). Sir Daniel Cooper presided.

Mr. JAMES GRAY (the Secretary) read the notice calling the meeting and the above resolutions.

The CHAIRMAN said: Gentlemen—This meeting has been convened to comply with the Companies Acts and the Articles of Association of the Corporation to confirm, or otherwise, the resolutions passed at our general meeting on the 5th of this month. You will all have received a report of the proceedings at that meeting, and you will have observed that the resolutions proposed at that meeting in favour of a reconstruction of the Corporation were carried unanimously. You have also been informed that meetings of the holders of the First and Second Mortgage Debentures have been held, and that the scheme of reconstruction has been adopted by them, and if you confirm to-day, as I hope you will, the resolutions which I now propose, then the new Company will be registered to-day, and will take over the business of the Electric Construction Corporation and all its liabilities and assets as from the 1st of this month, and although there may be still several formal steps to be taken for the purpose of completing the matter, yet, practically speaking, the reconstruction of the Corporation will be effected by your confirming the resolutions to-day. I may tell you that the support we have received from the shareholders in favour of the resolutions now before you is even larger than the very gratifying support we had at the last meeting. It is not necessary for me to detain you any longer now. Before concluding, I may tell you that in accordance with the Companies Acts we shall have to hold a general meeting of the new Company within four months, so that we shall have an opportunity at an early date of meeting you again, and giving you further information in regard to the position of the new Company. I have, however, to add that after the special resolutions have been confirmed a further resolution will have to be proposed by the Chairman and seconded by the Right Hon. David Plunket, that Mr. Philip Edward Beachcroft and Mr. Emile Garcke be appointed joint liquidators of the Electric Construction Corporation, and that they be instructed to give effect to the special resolutions for winding up the Corporation with a view to its reconstruction.

Mr. BARCLAY having seconded the resolutions,

The CHAIRMAN invited discussion, and there being no questions asked he put the first resolution to the meeting, and it was at once carried unanimously. He then, with the permission of the meeting, put all the resolutions, from 2 to 8 inclusive, *en bloc*, and they were also carried unanimously.

The CHAIRMAN then moved that Mr. Philip Edward Beachcroft and Mr. Emile Garcke be appointed joint liquidators of the Electric Construction Corporation (Limited), which was seconded by the Right Hon. D. PLUNKET, and carried.

A vote of thanks to the Chairman having been moved and seconded,

The CHAIRMAN, in reply, said: Gentlemen, I have to thank you for your vote. I have not had much anxiety to-day. I can assure you that myself and the whole Board of the Directors feel very greatly indeed the kind support that you have given us under adverse circumstances. We trust that we may rely upon its continuance. We feel that we are very much indebted to you, and we thank you very cordially that you have given us such very great support.

The proceedings then terminated.

National Telephone Company (Limited).

The thirteenth annual ordinary general meeting of this Company was held at the City Terminus Hotel on Tuesday last, the President (Mr. James Staats Forbes) in the chair.

The SECRETARY (Mr. A. Anns) read the notice convening the meeting, and the Directors report and statement of accounts were taken as read.

The CHAIRMAN said that there were on the register 6,721 shareholders and 1,680 debenture-holders, making a total of 8,401 partners in the concern. There were so many points of interest in connection with the report and accounts that he hardly knew how to tackle them. Beginning with the first paragraph of the report, which, after all, contained the kernel of the nut, the year in respect to which these accounts were presented had been one of progress—in the sense, at all events, of spending the shareholders' money freely, for reasons which he would enlarge upon as he went along. The facts were fully set out in No. 1 account, and comprised the gist of the observations which he would have to make on the subject. They would see on the debtor side of the account very considerable additions in the form of several new undertakings. The policy of the Board for the last few years had been to bring into brotherhood all the subsidiary companies. The amalgamation with the three great companies which became the National Telephone Company (Limited) showed them the wisdom of fusion so strongly that they had from time to time, as opportunity offered, induced the other companies which were even less important to join this Company, with the result that they were now practically all absorbed. They would see a small number of names of these undertakings in the capital account. There was the Western Counties and South Wales Company (Limited), which was the most important, and which was absorbed at a cost of £277,607. Then came the telephone business of the Sheffield Telephone Exchange and Electric Light Company (Limited), which cost £38,696—an institution in which electric lighting and telephony were combined. The Directors of the National Company did not covet the electric lighting, but they bought the telephoning business of that Company. Some other minor companies were absorbed, all of which brought up the total to the not inconsiderable sum of £345,776. The result was that areas, not before within their government, were now brought into it. The business was progressing, and the subscribers increased in number. The peculiarity of this business—he did not know that it was a peculiarity—was that every single new subscriber meant a special outlay. It was somewhat different from other enterprises, like a railway, which involved a large first cost, as to which they knew how they stood. The peculiarity consisted in this, that money had, from time to time, to be advanced three, four, and six months in advance of the completion of the work which produced their income. The other capital charges amounted to £305,799. That was a very large sum of money to spend in the course of the year—£651,575—and that money had to be provided. It was provided by the issue of certain of their stocks amounting to £595,000 in round numbers, and these subscriptions, of course, brought upon the year certain charges which made their influence felt when they came to the net revenue account. The Directors in their report called attention specially to the large expenditure in the acquisition of the other companies. They said that it was policy to do it, and although it had entailed a large amount of outlay they were prepared to take the responsibility of having done so, believing that they would have the approval of the shareholders for their action. There were some other charges which he would have to advert to later; but having got into their minds the foregoing facts, he would pass on to the consideration of what had been done during the year. Of course he need hardly say that money spent in the way described—that was to say, either in the acquisition of other companies or in the extension of the Company's business—was not immediately productive. It took some little time to bring about results. He did not think that they had done badly, because if they turned to the net revenue account it would be seen that there had been a considerable addition to the business of the Company. He had occasion at the previous meeting to impress upon the shareholders the necessity of finding some principle or factor by which they could measure approximately their exact position. In a railway company it was the train mile which was a familiar thing to them that determined it, as it was of a fixed significance. They had tried to find some method of fixing a standard of comparison, and the nearest approach to that was the wire, not the subscribers. Some subscribers, it was true, used more than one wire, some having two and others three; but each wire entailed a specific expenditure, and a multiplication of wires meant a multiplication of business; and therefore a wire might be looked upon as an instrument by which comparisons might be made. It was the nearest thing that they could find by analogy to the train mile of a railway. The progression of wires, of course, was, therefore, one of the means of measuring the progression of business, and in the year they had increased from 47,878 to 59,631 wires, or a difference of 11,153. He must qualify that by reminding them that they brought in during the period under review the *corpus* of the Western Counties, &c., Telephone Company, and when it was taken over it had about 4,000 wires, and deducting these, the normal progression of business had been 7,153 wires in their area during the year. It was just as well to dispel illusions which existed in the minds of some people outside, as to what it meant to put on a new subscriber. The average cost was something like £42 per subscriber per wire. Some people had an idea that it could be done for much less. In their undertaking he believed that the experience and skill at their command enabled them to tell exactly the right thing to do, and to do it in the most economical and best fashion possible, and that was the figure at which it worked out. Coming to the paragraphs in the report, he believed that the language contained therein was almost exactly the same as that used in preceding reports—it was only the figures which were altered. The income accrued in respect of the business of the year amounted to £583,590, which was an increase of £119,848 over that of the preceding twelve months. He must remind them again that both the Sheffield Company and the Western Counties Company were included in the account, and their income, which subsisted last year before they came into the scheme of amalgamation, was incorporated bodily in the account. The rentals carried forward this year for unexpired terms of running contracts amounted to £285,020, or an increase of £50,649 The working expenses and other charges, excluding debenture and other interest, had increased by £75,392, which was a very large advance in proportion to the increase of business, namely, £119,848. Like the income of the Western Counties and the Sheffield Companies which came in to swell the gross receipts, the expenses connected with the new areas contributed to swell the working expenses, and with this disadvantage that those areas were more sparsely populated. The income per subscriber therefore was relatively less, and the outlay was relatively more in the bigger undertaking. To this extent, so to speak, the averages were diluted. The net result for the year, after deducting the Post Office royalties amounting to £54,220, which was a pretty stiff tax to levy on a Company like this, was a profit balance of £217,725, or an increase of £30,475 over that of the preceding twelve months. They were always being pulled to pieces because they did not reduce their tariffs. Most of them had a slight interest in that, but the reduction of tariff meant that their expenses were not diminished, and he wished proprietors to turn that over in their minds and master it. They had to remember that all reductions came out of one pocket, namely, profit, and in this enterprise, although he believed that it was very sound, and its future might be looked upon as assured, a small reduction might have a very large effect on the dividend; and if they took the figures before them to pieces it would be found that they were not in such a position as to be enabled to make any very great reduction. He did not know why this Company and its service deserved all the odium frequently cast upon them by the unknowing. The curious thing about such undertakings was that people who knew nothing about them were always ready to dictate what ought to be done. Such people were not concerned as to whether what they suggested was either wise or economical. They contrasted the state of things in New York, Boston, St. Petersburg, or Berlin, in which the circumstances were so entirely different as to produce a very serious effect upon profit. He would give a few figures which spoke eloquently in favour of

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the Company since its fusion. The first year's business—that was to say, in 1890—realised an average receipt throughout the year from those served by the Company of £14. 11s.; while in 1893 the average was reduced to £9. 17s. 9d., and he ventured to say, with the greatest respect to all critics, that there was no comparison between that charge and that of any other great city in Europe, not even including Berlin. In 1890 the proportion of expense was 49½ per cent., while this past year it had been 62 to 65 per cent. of the revenue. The reduction came out of their pockets; further expenses were relatively a fixed figure. The number of lines had increased from 36,000 to 39,131, and, as they knew, the dividend was 6 per cent. Was 6 per cent. an unreasonable return in such a venture as theirs? Let them think of the danger they had undergone in making a new business, and under such disadvantages as he supposed no other commercial company had ever experienced. They could not compare their undertaking with those of other great cities. Let them take Paris, if they liked, or St. Petersburg, Vienna, or any other city where telephonic business was carried on, all of which, by way of comparison, were cast in their teeth. He would very much like to dissect the accounts of some of the companies doing business there as he dissected those of the National Company. He was sure that he would make out that many of them must be worked at a loss, and not at a profit. In London everybody said what a scandalous thing that people paid absolutely £20 for their service. This was perfectly illusory, because if those people chose to pay for a term they could get their service for less. It was surely not unreasonable to charge a high rate for a service for a short time. The average cost for the past year had been £15. 0s. 7d. per assured tenancy, which could not be compared with the charges in some other cities. London was three times as big as Paris, and proportionately much larger than the other cities which he had named, and the whole area was included in a subscription, and the work was carried on under extreme disadvantages. Amongst others was that in London they had to pay £1. 4s. for wayleaves for every wire. In Berlin, in Paris, and in many other cities he knew they did not pay much for wires. This Company paid to the Post Office £1. 6s. 9d. by way of royalty, and he maintained that, looking at the area covered and the circumstances under which the business was carried on, London was the cheapest city in the world. He was willing to accept the challenge of any expert on the figures, if such a one were bold enough to challenge them. The net result for the year, after deducting the royalties referred to, was an increase of £30,475. Now what were they going to do with this balance? They proposed to pay a dividend of 5 instead of 6 per cent. for prudential reasons. They could, of course, have paid 1 per cent., more, but they had to consider the character of the business, and whether it was not a prudent thing, and such as commended itself to men of sense, to pay a dividend—not so bad as these times went on and consols diminished in value—which they could maintain and which would put them in a stronger financial position. The Directors did not ask the shareholders to accept a smaller dividend with a light heart, but they came to the conclusion that it was their duty, having a fuller knowledge of the circumstances of the past and present and those that were likely to arise, to recommend, if not to urge upon the shareholders to accept the reduction. He thought that he had said enough about the financial part of the business, but he would be glad to answer any questions that might be asked on the figures. He now came to paragraph 8 of the report, referring to the acquisition by the National Company, partly by purchase and partly by the exchange of the New Company's shares for National shares, of nearly the entire interest in the New Company. The paragraph, he said, disclosed the whole story of the transaction. They were in the midst of the negotiations under which they were to become partners to a certain extent in the undertaking alluded to when the policy of the Government was commenced. The late Duke of Marlborough, who was a most capable man and the moving and enthusiastic spirit of the New Company—and who would not take no for an answer—was extremely opposed to what the Government was to do. He was brought into close contact with the Directors in considering what was to be done, and the best thing that he saw was to fuse with this Company. The universality of this business and its administration was so apparent that competition in it meant disruption. The Government had the right of taking over the telephone enterprise any day it liked by agreement, and so far its action meant disruption, which seemed to be the policy of some Governments; but they had not done so, but had elected that the Company should go on, but they were uncomfortable that they had not got their fingers in the Company's pie, and decreed that the most difficult and costly part of the business should be committed to the Company, but that they should keep the arterial part of the business in their own hands. They were, in fact, going to have two departments to do the work of one. The negotiations had been somewhat protracted, for he did not think that the Post Office exactly understood the position; but the Company had been forced into the policy it had adopted. Paragraph 10 spoke for itself. Their business was becoming very extensive, and it would still further extend. They had many critics, it was true, but they had many friends, and they had to do very delicate work. The rapid growth of the business of the Company, and the increasing responsibilities of the Board, involved in the closer relations with the Post Office, induced the Directors to make some change in the Directorate by importing into it some gentlemen of public position and experience. That, of course, was not done without some sense of regret, for all the members of the Board worked so harmoniously together, and their work was very fascinating. Indeed, he had never known anything so fascinating as telephony. He could not get away from it. He thought that the thanks of the proprietors were due—and he was sure they would be readily accorded—to Messrs. John Bruce and Peter Garnett for the self-sacrifice they had made by their voluntary retirement from the Board so that it might secure the services of Lord Balfour of Burleigh and Sir Albert K. Rollit, M.P., who could not fail to be a great acquisition to the Company. He concluded by moving the adoption of the report and accounts, and the payment of a dividend for the half-year at the rate of 6 per cent. per annum (tax free) on the First and Second Preference Shares, and 5 per cent. on the Third Preference and Ordinary shares, making the dividend for the year 6 per cent. on the First and Second Preference Shares, 5 per cent. on the Third Preference Shares, and 5 per cent. on the Ordinary shares.

Lord BALFOUR, in seconding the resolution, said that after the exhaustive speech of the Chairman on the last year's work of the Company, there was very little for a comparatively new comer like him to enlighten the shareholders upon. At the same time, after the kindly way in which his name as a Director had been received, it would be ungrateful if he did not in a word or two say with what pleasure he had joined the Board of the Company, and taken a small part of its management. He came into it, as the Chairman had said, with a fresh mind looking at things rather from an outside point of view. But he would like to say once for all that although he had been engaged in some other enterprises he had never associated himself with a body of gentlemen more harmonious among themselves or more energetic or single minded in the service of the concern which they had undertaken to direct. He quite felt the fascination for the business to which the Chairman had alluded, and he hoped that with a little more experience he might be able to do good work in the interests of the Company and his own, which were identified with the Company. The Chairman had alluded to the progress which the business had made during the last year, and said that it was progress to some extent made up of the spending of the money of the shareholders. But the expenditure had had some definite results. He thought that it meant the providing of the material for the service of the Company, not only in London, but in many of the most populous parts of the provinces, and it had had also a most gratifying result in extending and developing the business acquired in previous years. He did not think that the Chairman had said enough about the complexities and difficulties which the officers of the Company had had to face in managing the London business. It was all very well to compare London with Paris, Berlin, or Vienna, but anyone who had studied the matter knew that with a business of this kind London stood alone. No city presented such complexities in the matter of telephony as the metropolis. They had got, he believed, a sound and a steadily-increasing business, which, in his humble opinion, required only care and forsesight to develop it into a prosperous property. It was not every company that could claim after so short a history to pay £54,000 by way of royalties and yet be able to declare a dividend. He thought that that was a very severe tax, but it was a condition imposed on the Company, and it said something for the energy of the officers that the Company was able to pay it and maintain a dividend of 5 per cent. Something had been said about the exhorbitant charge of £20 for the service, but let them think what they got for the service compared with what it would cost to conduct their business by the telegraph instead of the telephone. What could they do for £15 by the former in the course of a year? He cordially supported the resolution of the Board to pay only 5 per cent. instead of a 6 per cent. dividend because he thought that to pay a steady distribution of that kind would be a careful regard to the necessities of the future was the wisest course which they could pursue. That was the course which the Board recommended to the proprietors

The CHAIRMAN, in reply to the Rev. M. BLACK, explained that the item £397,580 represented the cost of acquiring the shares in the New Telephone Company (Limited). They subscribed a third of the original capital, and since then they had availed themselves of acquiring nearly the whole of the existing interest. What they had got in return was a business of that Company in Manchester, and that of one or two small centres outside that City, and certain agreements in London said to be of very great value. With respect to the reserve fund he thought that it was very fully discussed at the last meeting. Some companies when they put aside a reserve fund invested it and set it out in their balance-sheet as being locked up in this, that, or the other security. The Directors of the National Company had invested theirs so far in their business, partly as a matter of judgment and partly from the circumstances of their position. If they had to raise, say, £130,000, for the purpose of extending their business, they would have probably to pay somewhat more for it than by putting it to a reserve fund. They were extremely well represented in Glasgow, where the Corporation was moving in the direction of establishing a local telephone.

A SHAREHOLDER asked whether the £397,580 was money paid out of pocket.

The CHAIRMAN replied that it represented money subscribed to acquire the business of the New Telephone Company (Limited).

Mr. LEAK asked what would happen when the licenses of the Company expired.

The CHAIRMAN replied that some provision would have to be made against that contingency. Hence the necessity for paying a small dividend and having a big reserve. What he thought was that they would be disposed of by absorption by the State.

The motion was then put to the meeting, and carried unanimously.

The retiring Directors, Lord Balfour of Burleigh, Sir Albert Kaye Rollit, M.P., Mr. Charles Swain Agnew, and Mr. George Hunter Robertson, were then severally re-elected to their seats at the Board. Each of these gentlemen expressed his acknowledgment for the compliment, Sir ALBERT ROLLIT taking occasion to remind the meeting of the great interest which he has taken in telephony since its introduction into this country. He further wished to confirm the remarks of the Chairman in reference to the late President, the Duke of Marlborough. He thought that there ought to be no difficulty in reconciling public and private interests in the matter of telephony, and the best way to secure this object was to give an efficient service.

The auditors (Messrs. Welton, Jones, and Co.) were afterwards reappointed, and a cordial vote of thanks having been accorded to the Chairman, who gracefully acknowledged it, the proceedings terminated.

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NEW COMPANIES, STATUTORY RETURNS, &c.

In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1893, pages 320-348, *&c., &c.*]

ELECTRIC AND AUTOMATIC ENGINEERING COMPANY (LIMITED).—This Company was registered on the 15th inst., with a capital of £10,000, in £1 shares, to purchase or otherwise acquire any patents, patent rights, licences, inventions, or other privileges, for any system or process for the working of automatic supply boxes or machines, by mechanical, electrical, or other power, and for the production of electric currents, to manufacture, sell and deal in chemicals for the generation of electricity, and to develop and to turn to account the said patents.

GRAVIER DYNAMO SYNDICATE (LIMITED).—This Company was registered on the 13th inst., with a capital of £10,000 in £1 shares, to enter into an agreement with Alphonse J. Gravier, for the acquisition of certain patents, inventions, and patent rights, particulars of which do not transpire, and generally to exploit and turn to account the same.

JAMES CARMICHAEL AND CO. (LIMITED).—This Company has been registered with a capital of £65,000, divided into shares of £10 each, to acquire and conduct the business of engineers, ironfounders, boilermakers, &c., in Dundee, carried on by James Carmichael and Co.

MANCHESTER STEEL NUT AND TUBE COMPANY (LIMITED).—This Company has been registered with a capital of £80,000, in £10 shares, to acquire the business of steel nut and tube makers in all its branches, as now carried on by Edward Cope, under the style of the Steel Nut and Tube Company, and to develop and extend the same; also as mechanical, electrical, hydraulic, and marine engineers, tool makers, &c., &c.

STANNUM METAL COMPANY (LIMITED).—This Company was registered on the 15th inst., with a capital of £40,000, in £1 shares, to acquire and exploit the British patents of C. L. C. Bertou, in connection with an improved process for the recovery of tin and iron from waste clippings of tinned sheets, and also for improvements in the process of precipitating oxide from acid solutions containing same with other metals, and to carry on the business of mechanical engineers, machine, and general tool makers, electrical engineers, electricians, suppliers of electricity, and manufacturers of appliances used in the generation, supply, distribution, and employment of electricity.

WEST INDIAN DEVELOPMENT COMPANY (LIMITED).—This Company was registered on the 13th inst., with a capital of £5,000, in £1 shares, to enter into an agreement for the sale to the Company of a concession made to J. K. D. Mackenzie, by Act of Parliament, to enable him to supply electricity for the purpose of lighting the City of Bridgetown, in the Island of Barbados, and to carry on (*inter alia*) the business of electricians and electrical engineers.

ANDREWS AND PREECE (LIMITED).—The 1893 return for this Company, recently filed, shows that while the nominal capital is £25,000, divided into 300 Deferred shares of £10 each, and 2,200 Ordinary shares of like value, only 418 Ordinary and 300 Deferred have been taken up. All the Deferred and 226 of the Ordinary shares have been taken up. The full amount has been called on the remaining Ordinary share capital, resulting in a payment of £1,865, and leaving £55 as yet in arrears.

CAMBRIDGE UNIVERSITY AND TOWN ELECTRIC LIGHTING COMPANY (LIMITED).—When the last return was filed on the 10th inst. only the shares of the seven original signatories were taken up, no calls having been made.

CHINA AND JAPAN TELEPHONE COMPANY (LIMITED).—The annual return of this Company, made up to May 30, 1893, has been filed. Out of a nominal capital of £20,000, in £1 shares, 14,761 have been taken up, of which all were issued as fully paid. The Oriental Telephone and Electric Light Company (Limited) hold 14,101 of these shares.

CHELSEA ELECTRICITY SUPPLY COMPANY (LIMITED).—The annual return of this Company, made up to March 16, 1893, has been filed. The nominal capital is £100,500, divided into 14,000 Ordinary and 6,000 Preference shares of £5 each, and 500 Founders' shares of £1 each; 9,277 Ordinary and 500 Founders' shares have been taken up, of which 5,666 Ordinary and the whole of the Founders' shares have been issued as fully paid. The full amount has been called, and £18,055 has been paid on the remaining 3,611 Ordinary shares.

CROMPTON-HOWELL ELECTRICAL STORAGE COMPANY (LIMITED).—The annual return of this Company for 1892, made up to August 17, 1892, has recently been filed. The nominal capital is £19,600, divided into six Founders' shares of £100 each, and 19,000 Ordinary shares of £1 each. All the Founders' and 12,006 of the Ordinary shares have been taken up, the full amount called on the Founders' shares, while a call of 15s. per share has been made on the Ordinary shares, resulting in a total payment of £9,604. 10s. The return for 1893 made up to March 25th and also recently filed, exhibits no change from the foregoing.

CUTTRISS, WALLIS, AND CO. (LIMITED).—The second annual return of this Company, made up to June 16th, and recently filed, shows that 771 of the 2,000 shares of £5 each have been taken up; 420 shares have been issued as fully paid, while the full amounts have been called, and £1,755 paid on the remainder.

DALZIEL'S ATLANTIC TELEGRAM COMPANY (LIMITED).—The annual return of this Company, made up to May 16, 1893, and recently filed, shows that 150 fully-paid and 73 "subscribed" shares of £100 each have been taken up out of a nominal capital of £25,000. Upon the "subscribed" shares a call of £50 per share has been made, resulting in the payment of £3,850, leaving £50 in arrears; while £50 has been paid in advance of calls.

CITY NOTES, &c.

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend for the quarter ended June 30th last of 12s. 6d. per cent. on the Ordinary stock and 25s. per cent. on the Preferred stock, less income-tax, payable on August 1st to stockholders registered on the books of the Company on the 10th inst.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended July 16th were £774, as against £766 for the corresponding period of last year, being an increase of £8. The total receipts for the half-year amount to £1,843, against £1,499 in the corresponding period of 1892, being an increase of £344. For the past half-year the accounts show a balance, after providing for the Debenture interest and the full dividend on the Five per Cent. Preference Shares, sufficient to allow the payment of a dividend on the Consolidated Ordinary Stock at the rate of ¾ per cent. per annum, against ½ per cent. for the corresponding period of last year, leaving £898 to be carried forward.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The Directors of this Company have decided to recommend a final dividend of 3s. 6d. per share, free of income-tax, to be payable on and after the 29th inst., making, with the interim dividends already paid, 3½, per cent for the year ended June 30th last. After placing £3,000 to reserve fund account, a balance of £819. 2s. 4d. is carried forward. The transfer books of this Company will be closed from the 14th to the 28th inst. inclusive.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company notify that the coupons of their Five per Cent. Debentures, due August 1st, will be paid on and after that date by Messrs. Glyn, Mills, Currie, and Co., 67, Lombard-street, E.C. Coupons should be left three days for examination.

EDINBURGH ELECTRIC SUPPLY CORPORATION (LIMITED).—At an extraordinary general meeting held on Tuesday, the resolution passed a month ago, voluntarily winding up the Company, was confirmed.

EUROPEAN GAS COMPANY (LIMITED).—The annual general meeting of this Company was held on Monday last at the offices, Austinfriars, E.C., with Mr. J. Blacket Gill in the chair. The Secretary and General Manager (Mr. Williams) read the report of the Directors, which stated that the Company's business had been well maintained during the year. There had been a falling off in the consumption of gas at Boulogne and Nantes, where the competition from the electric light had been felt somewhat severely; but the Directors had reason to hope that the decrease at these stations was but a temporary one, for in other towns—notably, Amiens, Rouen, and Havre—they were able to report a considerable increase of business, in spite of similar competition. In connection with the development of electricity the Board would remind the shareholders that every effort was made to extend the use of gas for cooking, heating, and motive-power. The Chairman, in moving the adoption of the report, said he thought they might congratulate themselves upon the increase of 1 per cent. in their rental. He had paid a visit to their stations during the past year, accompanied by the General Manager. He had not previously been for two years, and he was very much struck to notice how greatly the electric light had gained ground in the interval. There were very few shops of importance which were not lighted by electricity in the towns which their Company supplied with gas, excepting Cannes, and this competition, of course, they felt very keenly. The *cafés* were large consumers of the electric light. Many of the people would say that they paid more for electricity than for gas, but that they were compelled to follow suit when their rivals adopted the electric light. They had about 38,000 stoves on hire, as well as 250 gas-engines, with the result that about 25 per cent. of their total consumption was in the day-time. So far, this was a class of business with which electricity could not interfere.

KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY (LIMITED).—The interim dividend warrants for the past half-year on the First Preference shares at the rate of 6 per cent. per annum have been posted. An interim dividend on the Ordinary shares at the rate of 4 per cent. per annum will be payable on the 31st inst.

SHEFFIELD ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The second ordinary general meeting of shareholders of this Company was held on Thursday last at the offices, in Commercial-street, Sheffield. The Chairman, Mr. George Franklin, said that in view of the growing demand for the electric light it had been found necessary to rebuild and enlarge the central station in order to make room for new steam and electrical plant, which would be of the most modern description, and would probably be at work during the autumn. The station would have an ultimate generating capacity of 80,000 lamps. Twelve and a-half miles of underground conduits had been laid in the streets for the reception of the distributing cables. The prospects of the Company were most encouraging, and a new issue of 4,000 Ordinary shares would be probably made in the near future. A dividend of 5 per cent. per annum was declared, free of income-tax, and the retiring Directors were re-elected.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LTD.).—The transfer books of this Company will be closed from the 17th to the 25th inclusive, preparatory to the payment of an interim dividend of 12s. per share to shareholders on the register on the 17th inst.

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WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended July 14, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,346.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the two weeks ended July 15th were £1,880, as compared with £2,084 for the corresponding period of last year.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 12.	Price Wednesday, July 19.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 19. Highest	Lowest
			TELEGRAPHS			£ s. d.			
£1,134,640	Stock	12/6	Anglo-American	51 52	50½ 51½	5 5 5	Jan. Apr., July, Oct.	51	..
£2,932,680	Stock	25/0	Do. Preferred	94 95	94 95	5 15 9	" "	95	94
£2,932,680	Stock	5/0	Do. Deferred	10 10½	9⅝ 10	..	.. ..	10½	9⅝
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	99 102	99 102	3 18 5	January and July	100½	100⅝
130,000	£10	3/0	Brazilian Submarine	11⅞ 12¼	11⅞ 12¼	5 6 1	Mar., June, Oct., Dec.	12⅛	11⅞
£36,400	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	106 110	106 110	4 10 11	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	138 142	38 142	4 18 7	April and October	..	..
16,000	10	8/0	Cuba Submarine	11½ 12½	11½ 12½	6 8 0	February and August	12	..
6,000	10	10%	Do. Preference 10 per Cent.	18½ 19½	18½ 19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½ 3½	2½ 3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅞ 12⅛	11⅞ 12⅛	5 15 8	Jan., Apr., July, Oct.	..	..
400,000	10	2/6	Eastern	15½ 15⅝	15 15¼	4 5 3	" "	15½	15¼
70,000	10	6%	Do. 6 per Cent. Preference	16½ 17	16½ 17	3 10 7	" "	16⅞	..
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112 115	112 115	3 9 7	May and November	..	..
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	108 111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension xd	15¾ 16	15½ 15¾	4 7 0	Jan., Apr., July, Oct.	15⅛	15⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	113 116	113 116	3 9 0	February & August	113½	..
£70 600	100	5%	Do. 5 p. c.(Austln. Gov. Sub.) Debs 1900	102 105	102 105	4 15 3	January and July	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent Mor Deb.,1900	101 104	101 104	4 16 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	102 105	102 105	3 16 2	February & August	104½	..
£200,000	£25	..	Do. 4% Mauritius Sub. Debs...prem.50% paid	3½ 4	3⅝ 4½	..	May and November	..	..
180,227	10	2/3	Globe Telegraph and Trust	9⅝ 10	9⅝ 10	4 10 0	Jan., Apr., July, Oct.	10	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	15⅝ 15¾	15⅝ 15⅞	3 15 7	" "	15⅛	15⅛
150,000	10	5/0	Great Northern	19½ 20	19⅝ 20	4 5 0	Jan., April, and July	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures. 1883 issue	105 108	105 108	4 12 7	March & September	..	..
17.000	25	37/6	Iado-European	39 42	39 42	5 19 1	May and November	..	..
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	6 13 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent Debentures	107 110	107 110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs.	100 103	100 103	3 17 8	..	..	..
11,802	8	4/0	Reuter's	5 6	5 6	..	April and October	..	..
3,381	£100 Cert.	30 0	Submarine Cables Trust 6 per Cent.	120 125	119 124	4 16 9	" "	..	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July	..	..
£260,900	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	3 4	3 4	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	99 103	97 101	7 18 5	June and December	99⅞	..
88,321	10	6d.	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	..	..	1⅛	1⅛
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 11	10½ 11	5 9 1	May and November	10½	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9½ 10¼	9½ 10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	105 108	105 108	4 12 7	June and December	..	..
64,242	15	4/6	Western and Brazilian	7½ 7¾	7½ 7¾	4 13 11	May and November	7⅝	..
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	6 6½	5⅞ 6¼	..	..	6⅛	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1½ 2	1½ 2	..	..	1⅝	1⅜
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106 109	106 109	5 10 1	February & August	108½	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106 109	106 109	5 10 1	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120 125	120 125	5 12 0	May and November	..	..
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	2 3	2 3	..	..	..	..
224,850	14/0	3½d.	Consolidated Telephone Const. & Maintenance	⅛ ¼	⅛ ¼	..	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	¼ ½	¼ ½	7 18 2	Yearly	..	..
458,867	5	2/6	National	4⅝ 4¾	4⅝ 5	5 0 0	June and December	4⅛	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14⅜ 15¼	14⅜ 15¼	3 18 8	" "	15⅝	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14¼ 14⅜	14¼ 14⅜	4 1 4	" "	14⅛	..
90,950	5	6⅜d.	Do. 5% Non-Cumulative 3rd Pref (£5 paid)	5⅜ 5⅝	5⅜ 5⅝	4 8 11	.. ..	..	..
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	110 115	110 115	3 18 3	January and July	113¾	112⅝
58,000	5	1/0	United River Plate	2½ 3	2 2½		January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	10½ 10¾	10⅝ 11½	..	..	11½	11
20,000	10	..	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12¾ 13½	12⅝ 13	..	..	12⅛	12⅛
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	5 5½	5 5½	..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
8,322	£5	..	House to House Electric	1⅞ 2⅛	1⅞ 2⅛	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	5⅜ 5⅝	5⅜ 5⅝	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	6 6½	6 6½	..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4⅝ 4⅞	4⅝ 4⅞	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6⅜ 6⅝	6⅜ 6⅝	..	..	6	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6½ 7	6 6½	2 17 2	..	6⅝	..
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102 105	102 105	4 15 3	June and December	..	..
6,452	£10	..	Notting Hill Electric	5 6	5 6	..	..	..	..
19,980	£5	9½%	St. James' and Pall Mall	7½ 7¾	7 7½	..	..	7⅞	7⅝
20,000	£5	7%	Do. 7 per Cent. Preference	7¾ 8¼	8 8⅜	4 4 10	..	8⅞	8
59,900	5	2/0	Westminster Electric Supply (fully paid)	5¼ 5½	5½ 5⅝	3 10 10	..	5⅝	5½
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/6	Brush Electrical Engineering	3 3½	2⅞ 3⅛	..	..	3⅛	2⅞
75,000	2	6%	Do. 6 per Cent. Preference	2⅜ 2⅝	2⅜ 2⅝	5 1 1	..	2⅝	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107 109	107 109	4 2 7	March & September	..	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Cumulative Pref.	5½ 5¾	5 5½	6 1 9	January and July	5½	5
12,139	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	1⅜ 2¼	.. ..	..	..	..	..
49,900	10	12/0	Electric Construction	1½ 2¼	1⅜ 2⅛	..	..	2⅛	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜ ⅝	¼ ⅜	..	..	1⅛	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	..	..	..
50,000	10	15/0	India Rubber, Gutta Percha &c., Works	23 24	22 23	5 4 1	February & August	22⅞	22⅝
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	2½ 3½	2½ 3½	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	5/0 6/0	4/0 5/0	..	..	4/0	..
78,949	5	1/9	Swan United (£3. 10s. paid)	1⅞ 2¼	1⅞ 2¼	15 19 0	May and November	..	..
37,350	12	24/0	Telegraph Construction and Maintenance	33 35	33 35	5 2 10	March and July	..	..
£150,000	100	5%	Do. 5 per Cent. Bonds, red.1894	101 104	101 104	4 16 2	January and July	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	5%	City and South London Railway	35 37	35 37	1 13 9	May and November	..	..
37,500	£10	£10	Liverpool Overhead Railway	4⅛ 4¾	4⅝ 4⅞	..	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 793.—Vol. XXXI. FRIDAY, JULY 28, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

In spite of its very modest dividend, the City and South ondon Railway continues to show satisfactory progress, and hough the total receipts (£23,159) for the first six months the present year are nearly 8 per cent., the passengers rried (3,146,656) nearly 12 per cent., and the train mileage 17,664) over 15 per cent. more than was the case this time t year, the total working expenses are £14,964, as against 5,098. The item of most interest to electrical engineers, e "locomotive and generating" expenses, has come down a most encouraging manner. When the line commenced eration these expenses were 9d. per train mile, this time st year they were 7·7d., this year they are under 6½d.

We have watched with no little interest the telephone-tube ying enterprise of the City of London Electric Lighting ompany, rejoicing to see two hitherto rival branches of the ectrical industry joining together to their mutual benefit id profit. At the same time we were curious as to the way which the Corporation would regard this union of interests. To take advantage of the privileges conferred after any years' negotiation upon an electric lighting company quietly run a network of telephone tubes was an excellent roke of business, and to get this *coup* blessed, so to speak, y an Act of Parliament was a still more brilliant achievement. It is, how ever, always dangerous in this country to trifle ith established institutions, and none the less so when they appen to be ancient municipal institutions; and the report f the Streets Committee, which was carried at Tuesday's neeting of the Commissioners of Sewers, is an illustration of his fact. As the matter now stands, sanction will not be given to the running of telephone wires in the tubes already aid, unless good instruments, double-wire circuits, and £8 entals are promised. This is, indeed, a vigorous push for an efficient and cheap telephone service, but we should like to know by what process the Streets Committee arrived at that £8. Was the formula by any chance:—Divide present rentals by two, and deduct £2 for injury done to corporate dignity?

The opposition which the National Telephone Company offered to the insertion of the Model Clauses in the Dublin Southern District Tramways Bill had considerable justification. The Telephone Company and the Tramway Company having already come to terms as to the clauses to be inserted, the former naturally objected to the substitution of other classes less favourable to itself, which were, as yet, unsanctioned by Parliament and in an embryonic state of development. Its final acceptance therefore of the Model Clauses suitably modified to meet the special circumstances of this particular case, may be taken as a sign that it recognises that the day is past for getting the telephones protected without regard to other considerations; although, acording to Mr. Pember, the National Telephone Company does not propose to peaceably permit the general adoption of the Model Clauses; "they wished to preserve their full freedom of opposing the Model Clauses on their merits or demerits at any future time."

The valid objection that it was impossible to adopt the Model Clauses because the Board of Trade regulations, their necessary appendages, were as yet non-existent, was got over at the Telephone Company's suggestion by so altering Clause 8 as to make any regulations that the Board of Trade might make in future of the same effect as if included in a schedule of the Bill under consideration. Again, the National Telephone Company urged in regard to the clause containing the proviso that it was after a certain number of years to have no ground of complaint against electric tramways unless the telephone circuits had been double-wired, that this proviso and Recommendation 6, suggesting the grant of statutory powers to run underground telephones, must be taken together, so that until the statutory powers were given it would be unfair to put the proviso in force. In the end, three years' grace was given to the Telephone Company, and the Board of Trade was empowered to extend the term, if necessary. A compromise which seems at once fair and practicable. From what has taken place in connection with this Bill, and the difficulty which is being raised in connection with the insertion of the Model Clauses in other tramway Bills, it is evident that the sooner Parliament confirms these clauses, and the Board of Trade draws up its regulations, the better—especially in view of the fact that it has the power to alter any regulations which, upon trial, prove impracticable.

The investigation by Dr. Sumpner on the action of combinations of coils and condensers when used with alternating currents, which will be found in our columns this week, is one to which electrical engineers may profitably turn upon the

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advent of the commercial condenser. Indeed, not only in that distant point of time—for commercial condensers suitable for high-pressure working seem to be a long time a-coming—but at the present, there is much of practical value in the general investigations and the useful set of curves which Dr. Sumpner contributes. It is to be regretted that there is the tendency, which he points out, on the part of mathematicians, to assume in their investigations values which are wide of those occurring in practice. For any conclusions arrived at in such a manner, however sound from a theoretical point of view, must fail to appeal to the practical engineer. There is no necessity for us to cite particular instances, where an alteration of the chosen values will make a vital difference in the character of the results; mathematicians are very familiar with them. One of the merits of these investigations is the entire absence of arbitrarily chosen magnitudes of this sort, and the wide range of practice over which the curves are consequently applicable.

We publish this week some details of an electric locomotive which has made its appearance in America. We regret that some of our American contemporaries have adopted an attitude of such jubilation over its introduction. The locomotive may be a creditable piece of work, but only a very little investigation of its capabilities will reveal that such expressions as "high-speed locomotive," and prophecies of the imminent millenium of electric railways, are quite out of character. In fact, when compared with a mere steam shunting engine, this "first practically operative high-speed electric locomotive in the world" (*sic*) must take quite a second place.

What is it that we really have in this wonderful engine? The draw-bar pull of 12,000lb. and the speed of 30 miles an hour look excellent, as, indeed, they would be if we could have both of them at the same time. But, unfortunately, we cannot; and, indeed, it is doubtful if we could have a 12,000lb. pull at all without finding the four driving wheels skidding violently on the rails. To give an adhesion of 12,000lb. the rails would require to be on a dead level and well sanded, unless the gross weight of the locomotive could be increased to considerably above 30 tons. On a gradient of 2 per cent. it is doubtful if the engine could start on more than 8,000lb. with an average condition of the track. Taking the normal starting effort at 10,000lb., there could hardly be more than one-tenth of this at full speed, even with the series-parallel device for starting the armatures. This would haul a load of about 80 tons on a dead-level track in good condition and with a fair side wind. With a bad state of rail, or against a high head wind, or up a stiff railway gradient, the capacity of haulage would be considerably lowered; and inasmuch as these conditions have to be allowed for in practice, it would seem nearer the actual mark to rate the locomotive as having about 30 tons capacity of haulage, over gradients not exceeding 1 per cent. Within the limits of adhesion it would, of course, always be possible to "link up" the locomotive to a higher load, at a sacrifice of speed and efficiency; just as, within the same limits, it is possible with a steam locomotive. But the practice would be vastly more wasteful with an electric locomotive than with its brother of the water vapour. In fact, it would never be tolerated by an experienced engineer, except occasionally over short lengths of steep gradient.

The proverb that a man must tell a second lie to hide a first seems to have its counterpart in engineering practice, for it is certain that if he once persuades himself that a certain piece of bad practice is good, he will be compelled to label "good" every other atrocious practice which is necessary to cover up the defects of the initial error. Once believe that black is white, and every raven is mistaken for a swan. The American practice of designing railway tracks to go round absurdly sharp curves and, sometimes, up sharp gradients at the same time, has its inevitable evil reaction in the design of locomotives and coaches. We cannot expect a coach with a stiff backbone to set half of itself almost at right angles to the other half, so we must give it the flimsiness of a centipede by some such arrangement as the "radial truck" which is in so much favour in America just now. The fault does not so much attach to the truck itself as to the line for which such a defective truck is necessary. The principle involved is equally applicable to other branches of engineering. Bad practice leads to more bad practice, whether in the design of railways, steam engines or dynamos. What, to cite another example, could be more reprehensible than the practice of designing a wasteful steam engine to "suit" a badly constructed dynamo?

We could wish that more town councils were able to discuss the *pros* and *cons* of municipal electric lighting in the sober business-like tone which characterised the debate on this subject at the last meeting of the Birmingham Town Council. The usual references to the "countless benefits to thousands yet unborn" likely to accrue from municipalising electricity supply may be eloquent, but they certainly are not argument. At Birmingham, however, they have sense enough to see that there need be no fear of monopoly, nor, when the time comes for purchase in after years, of extortion. They also realise that whilst under the best conditions the business of electricity supply is a paying one, it is by no means generally so; and, consequently to undertake it would be largely a leap in the dark. Now speculation, whether municipal or metaphysical, is sadly unprofitable.

An esteemed technical contemporary does not like the common modes of talking about electrical things, and it exhausts an inordinate number of editorial notes in saying so. The sum of its objections seems to be that electrical terms do not convey to it the same ideas that they do to every electrical engineer; and the claim which it bases on the objections is that electrical engineers should forthwith and for ever stop using these electrical terms. "Passing current" is, for instance, a term which is to be tabooed, and, by implication, we suppose, the terms "stopping current" and "starting current." In fact, if we must be metaphysical, there is far more objection to the last two named phrases than to the harmless one, "passing current." For how can one start a current when there is not a current till

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it *is* started; or how can a current be stopped when in the very act it ceases to be? Instead of saying that "so much current" has passed through a cell, the expression "so much electricity" is recommended. This rather makes matters worse. The expression "current" is unfortunate, but is at present unavoidable; but the expression "electricity" in the sense of a quantity like energy or heat is almost as bad, and is easily avoided.

ELECTRICAL litigation in this country is, it must be confessed, a trifle dull, notwithstanding the amusing episodes which now and again arise owing to the tergiversation of experts whom our lawyers persist in treating as ordinary, every-day witnesses, although they are, as a matter of fact, and from the very condition of things, as full of bias as an egg is of meat. According to our New York correspondent's account of the latest development of the incandescent lamp litigation, however, they manage these things differently in America. GOEBEL, whom we were led to believe made commercial glow lamps before the Flood, only made them, one of his sons now swears, just in time for a recent trial. Other witnesses appear also to be going back upon all their previous sworn statements, and some of them seem likely to cross over from the civil to the criminal Courts. This is, indeed, exciting, but even with the dull season full upon us, we are glad the centre of disturbance is as far away as Milwaukee.

The Cost of Patenting.—To patent an invention throughout the world would cost something like £3,000.

Cable Interruption.—

	Date of Interruption.
Paramaribo—Cayenne	April 15th.

Hull.—At the last meeting of the Town Council Mr. A. H. Gibbings, electrical engineer to the Hove Commissioners, was elected to a similar post at Hull.

The West Hartlepool Time Gun.—On Monday, last week, the West Hartlepool time gun, which is fired by electricity from Greenwich, went off at five minutes to one o'clock, a flash of lightning having undertaken the duty.

European Electric Traction Statistics.—The electric tramways and railways of Europe now amount to about 270 miles, of which 105 miles are in Germany, 50 miles in the United Kingdom, 55 miles in France, and 25 miles in Switzerland.

Prof. Garnett.—Prof. Garnett has resigned his position as principal and professor of pure and applied mechanics at the Durham College of Science, to become Director and technical adviser to the Technical Education Board of the London County Council.

Municipal Telephony in Blackburn.—The Blackburn Corporation has just had fitted up for it a telephone system of 25 stations, connecting the Municipal offices, Police stations, gas-works, &c. The instruments used are Hunning's transmitters, and double-pole Bell receivers.

Atlantic Telegraphy.—The Commercial Cable Company announce that on June 13th, between the hours of 6:54 a.m. and 4:42 p.m. (9 hours 48 minutes) 807 messages were passed in one direction over one of this Company's main Atlantic cables, 2,388 miles long, being an average of 82·2 messages per hour.

Kingston-on-Thames.—The Electric Lighting Committee of this Borough are prepared to appoint a resident electrical engineer to take charge of the construction of the works for their electricity installation, and to have the management of such works when completed. For further particulars see our advertisement columns.

Eastern Telegraph Company.—This Company notifies that code messages may be accepted for Pernambuco at senders' risk, subject to receivers producing translations for inspection there. The prohibition of code by the Brazilian Government to all other parts of Brazil continues in force, but non-political plain language messages are delivered without restriction.

Rats and the Trolly.—It is stated that in some parts of Brooklyn there is a plague of rats owing to the exodus of the rodents from the car stables, the trolly having already supplanted about 2,100 horses on the Brooklyn City Railroad, which now has about 400 trolly cars in operation. The rats have therefore deserted the stables for better feeding quarters.

The Telegraphs.—In answer to a question, Mr. Arnold Morley stated in the House of Commons on Tuesday evening that comparing the total business done by the department in telegraph messages in 1892-3 with that done in the previous year, it would appear that the business was almost stationary. Any permanent addition to the force of telegraph operators under such circumstances was a matter which required serious consideration.

Mean Density of the Earth.—According to the latest determination of the mass and volume of the earth, by M. Berget, it would appear that the specific gravity of the earth may be taken at 5·4. The mass of the earth is given as $5{\cdot}85 \times 10^{27}$ grammes, and the constant of attraction as $6{\cdot}5 \times 10^{-8}$. Comparison between this constant and that for the attraction between magnetic or electric unit quantities will show how remarkably minute is the measure of the gravitational force between two unit portions of matter at unit distance apart. That this constant is independent of the nature of the atom is one of the standing wonders of molecular physics.

The Liverpool Tramways.—At the recent half-yearly meeting of the shareholders of the Liverpool United Tramways and Omnibus Company, Sir David Radcliffe, the Chairman, stated that the present lease had only about 11½ years to run. He mentioned that, he said, because it was the intention of the Directors to make another attempt to apply electric power as a means of haulage. Of course, before they could entertain the idea of building new cars and adapting them for mechanical appliances, they would seek an extension of the lease, as the capital outlay consequent upon a thoroughly different and new equipment of cars would be a very costly one, and one that could not be faced on a lease of only 11½ year's duration.

Government Grant to the Royal Society.—Among the numerous appropriations of the sum of £4,000, which is annually voted by Parliament to the Royal Society for the advancement of science, we notice the following which have been devoted to electrical research:—To Mr. R. P. Chattock, £10, for an investigation of the absolute measurement of the charge conveyed by the ions of an electrolyte; to Prof. C. G. Knott, £50, for an investigation of the effect of magnetism upon the internal volume of iron, steel, and nickel tubes of various bores; to Mr. H. L. Callender, £80, for a comparison of platinum and air thermometers; and to Prof. Dewar, £300, for his researches on the physical properties of liquid and solid oxygen, nitrogen, and air.

The Sims-Edison Electrically Controlled Torpedo.—Reports from Toulon give some account of experiments lately made there with the Sims-Edison torpedo by a special commission appointed by the Minister of Marine. On the 12th inst. the commission had three buoys moored at sea some distance from the Caraque battery, and the engineer of the Company was requested to steer round each buoy in succession, the object being to test the steering capacity of the torpedo. The sea was so rough that a successful result was hardly expected by the commission. However, the order to start was given, and it was then seen that the engineer had complete control of the weapon. The torpedo passed close round the first buoy, then round the second buoy, and then round the third. The Admiral ordered the torpedo to be stopped short and again started for the point of departure, which was done. During the run the torpedo appeared in no way troubled by the high sea. The length of cable paid out was 1,650 yards, the speed 11 knots, and the depth of water 180ft. On the 19th inst. a trial of speed was made; the sea was high, but a range of two miles was covered at a speed of 16½ knots. Although these trials, like previous ones, show the Sims-Edison torpedo to be eminently controllable, its speed is

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low and the maximum distance to which it can run is short. Warships are not likely to come within less than 3,000 yards of the shore nor likely to caught by a 16½-knot torpedo.

The Production of Hydrogen Peroxide in the Electrolysis of Sulphuric Acid.—In the *J. Soc. Chim. Russe*, XXIII., p. 235, M. Kuriloff has published a note on his researches on the production of hydrogen peroxide and of persulphuric acid when dilute sulphuric acid of different strengths is electrolysed, He employed for this purpose an apparatus which permitted the separate collection of the products formed at the two electrodes. The hydrogen peroxide was determined by titration with potassium permanganate, and the persulphuric acid by adding a known quantity of ferrous salt to the solution and titrating back with potassium permanganate. The results of his experiments are: (1) the quantity of hydrogen peroxide formed is very small; (2) hydrogen peroxide and persulphuric acid may be simultaneously formed at both electrodes, but the peroxide is not always accompanied by persulphuric acid; (3) the formation of both products is intimately connected with the concentration. Persulphuric acid only appears when the solution contains over 1 per cent. of sulphuric acid; hydrogen peroxide when the concentration is over 1 per cent.; (4) mixtures containing 3, 47, and 73 per cent. of acid respectively behave differently from other mixtures with regard to the amount of peroxide formed when they are electrolysed. This is considered by the author to be due to the fact that the composition of these solutions approximates to that required by the hydrates containing $(H_2O)_{1.5}$, $(H_2O)_6$, and $(H_2O)_2$, to each molecule of H_2SO_4, since, according to Mendeléeff, all these hydrates exist in solution.

Obituary.—We regret to announce the death of M. Marié Davy, which took place on July 16th at Clamecy, in the Department of Nièvre. Born in the year 1816, M. Davy lived to the ripe age of 77, and, though in later years he appears to have retired from the field of active scientific research, yet in earlier years he contributed many valuable Papers to, and took a prominent part in, the proceedings of the Académie des Sciences. His principal profession was that of an astronomer. Electricians have most cause to remember Marié Davy on account of the mercury sulphate cell which he invented. This was his principal if not his sole invention in the field of electricity; but it has served a useful purpose in its time, though latterly it has been replaced by the silver chloride cell, for accurate work, and by less expensive batteries, for commercial purposes. The object which Marié Davy had in the invention of this cell was the production of a high and fairly constant electromotive force. This he obtained by means of a zinc-carbon pair, the latter element being immersed in a paste formed of the higher or acid sulphate of mercury, a combination which gave one and a-half volts per cell.——We regret to hear that Mr. W. C. Palmer, assistant electrician to the General Electric Power and Traction Company, was drowned in the Thames on Saturday evening last whilst on duty. Mr. Palmer had only recently joined the Company.

St. Pancras Vestry.—A special meeting of this Vestry was held on Wednesday evening last week to consider Mr. Clements's memorandums on the electric light installation, and Mr. Gibb's replies thereto; also to resume the debate on the adjourned joint report of the Electricity and Dusting and Slopping Committees, recommending the combination of the destruction of refuse with the production of electricity, at the station in King's-road. It was resolved that the discussion should take place on the adjourned joint report of the two committees, to which the following amendment had been moved by Mr. Cox: "That the Vestry is not prepared to entertain the question of any other electric lighting installation until the present installation has been in complete working order for at least two years." Mr. Cox said he was not opposed to the electric light installation; in fact, he took a great interest in it, but he desired to see the Stanhope-street station in perfect order before they started another installation, and that the station should be in the right place. He denied that the defects were of a trivial character. The trenches were laid down under the belief that they were air-tight, but they were not—they were constantly being filled with water. The machinery, too, was constantly out of order; the condenser had never been in working order, though it had cost the Vestry between £400 and £500 to repair; there was a crack in the chimney; and the arc lamps could not be taken over because they were not in working order. Let them delay further action for the present, and see in the meantime whether they could adopt one large scheme to supply the whole of the parish. On Mr. Cox's amendment being put it was defeated by 51 to 22. The Committee's recommendation on being put as a substantive resolution was carried without a division.

Electric Car House Construction.—In the United States they have so many electric car houses and so many fires that it has become a question with the fire insurance offices whether they ought not to insist on a standard type of car house. In a recent number of the *Electrical Engineer* of New York, Mr. Alfred E. Braddell, who is connected with the Underwriters' Association of the Middle Department, says:—"It has been, I think, fully demonstrated that the great difficulty at the time of fire is the inability to remove the cars from the building, so that in many cases they have been entirely destroyed. To get over this difficulty it has been suggested to specify that the tracks be constructed on a gradient falling toward the entrance. If such is decided on the next question is what percentage of grade should be specified. . . . A number of well-known electrical engineers and railroad operators have been approached on this matter, with not very satisfactory results. The engineers suggest not less than a 3 per cent. grade, but this is objected to by the operators for many reasons, stating that the brakes would have to be continually applied, which they claim would cause their deterioration; also that with such a grade the cars could not be kept under proper control, being liable to move unexpectedly, perhaps injuring life and resulting in a suit for damages. Where, then, are we to strike the happy medium? The vital point is to have some method for rapidly removing the cars from the burning building, and the only feasible manner of accomplishing this appears to be a *safe* and *legitimate* grade. . . . On account of the enormous amount of capital being invested in electric railroads, I am sure this point is worthy of the utmost consideration. The subject is one peculiarly to be helped by discussion, as it is a new question in a new field, with little to be learned from horse railway precedents."

Birmingham.—At Tuesday's meeting of the Town Council the Mayor moved that the notice of the Birmingham Electric Supply Company to apply for a Provisional Order extending their area of supply should be referred to the General Purposes Committee. It appeared to the Committee, he said, that there were two grounds which might justify the Council seeking for powers themselves. The first ground was a reasonable anticipation that the profits to be derived would be large, and the second was that it was necessary in order to safeguard the interests of the consumers and the public generally. Putting together all the statistics that had been obtained, the General Purposes Committee had come to the conclusion that both in the case of companies and corporations the profits at present were inconsiderable, and there was no indication that they were likely to be very large. With regard to the second point the Corporation had power to apply to the Board of Trade to revise the prices charged every seven years. Besides this, there was no monopoly. On the whole the Committee came to the conclusion that it would be better, for the present at least, that they should not become suppliers of the electric light and power themselves. Alderman Johnson said a great many mistakes had been made through false analogies. There was no real analogy between the gas or water and the electric light. It was not like the water, a necessity of life; and it was not like the two gas undertakings, practically a monopoly. He was quite sure, as a matter of policy, it would be well for the Council to wait until a future time, when they would be able to acquire the undertaking, not at an extravagant premium, as in the case of the gas and water, but at the commercial value of the concern at the moment. The Mayor, in conclusion, said that the General Purposes Committee approached this question with a strong feeling in favour of the Corporation taking up the electric light, and it was only when they probed the matter to the bottom that they came to a contrary conclusion. The resolution was carried with one dissentient.

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ELECTRIC MOTIVE POWER.*

BY ALBION T. SNELL.

(*Continued from page 226.*)

The Conductor in Practice—Aërial Lines.

Proceeding to practical requirements, the first consideration is the metal for the conductor. In selecting this, the desideratum is all-round cost—*i.e.*, which metal will be the cheapest, taking into account the predetermined heat waste and conditions of erection and insulation. To guide the choice it is necessary, first of all, to know the specific resistance of the metals usually sold in the form of solid or stranded wire. Copper, or its alloys, and iron and steel are practically the only materials available for the purpose.

The resistance to the passage of an electric current in a wire of unit length and of unit area of cross section is defined as the specific resistance of the substance. The quantity thus designated gives a ready means of comparing the relative *electrical* suitability of the different metals.

Table E.

Metal.	Sp. resistance in microhms.	Specific gravity.	Breaking strain in lbs. per sq. inch.	Price per lb. in pence.
Copper annealed	1·615	8·8	—	8·5
Copper hard-drawn ..	1·642	8·9	56,000	8·5
Bronze (tin and copper)	4·42		84,000	10·0
Silicium bronze	1·7	8·4 to 8·7	90,000	
Phosphor bronze.....	3·0 to 60		—	12·0
Aluminium bronze.....		—	—	
Iron, ordinary, soft —	9·827		47,000 to	
Iron, galvanised, killed.	10·0 to 11·0	7·6 to 7·8	85,000	1·0
Steel, ordinary, soft ...	14·5 to 15·0	7·8 to 7·9	135,000	1·5
Steel pianoforte wire...	16·0 to 16·5	7·75	335,000	2·0
Manganese steel	73·0	7·8	110,000	3·0

The above figures are necessarily only approximate. The specific resistance determinations have been made at 32° F.

In Table E are arranged the copper alloys and various other metals in the order of their specific resistances; the specific gravity, breaking strain in lbs. per square inch, and the approximate price per lb. of the several metals are also given for rough comparison. It will be seen that iron has nearly seven times the specific resistance of copper, and so for a given resistance of line, the area of an iron wire will have to be, say, seven times that of a copper one. The specific weights are in the ratio of 8·9 : 7·8, and the weight of the iron line, relative to that of the copper line, will be expressed by

$$7\ W\ \frac{7{\cdot}8}{8{\cdot}9},\ \text{or}\ 6{\cdot}18\ W,$$

where W is the weight of the copper in lbs. And the costs will be respectively 8·5 W for the copper, and 6·18 W × 1 for the iron. A bare copper line will, therefore, cost about 27 per cent. more than an electrically-equivalent iron wire. From the simple consideration of first cost of conductor, then, it appears that iron is superior to copper. In relation to the total line cost, however, the reverse of this is the case. For the weight and breaking strain have to be taken into consideration. The breaking strain of hard-drawn copper of 98 per cent. conductivity is about 56,000lb. per square inch; whereas that of well-killed galvanised iron is about 85,000lb., so the spans may be made longer with iron wire in the proportion of 85 to 56; or, say, 50 per cent. Yet, since the iron wire is 6·18 times as heavy as the copper, the supporting devices must be correspondingly stronger. The figure of merit of a metal *per se* may be expressed as the product of the reciprocals of the specific resistance, the specific weight and price multiplied by the breaking strain—the best metal giving the largest figure of merit. Thus, for copper

$$\frac{1}{\text{Sp. R}} \times \frac{1}{\text{Sp. W}} \times \frac{1}{\text{Price}} \times \text{breaking strain}$$

$$= \frac{1}{1{\cdot}642} \times \frac{1}{8{\cdot}9} \times \frac{1}{8{\cdot}5} \times 56{,}000 = 450.$$

$$\text{For iron } \frac{1}{10{\cdot}5} \times \frac{1}{7{\cdot}8} \times \frac{1}{1} \times 85{,}000 = 1{,}040.$$

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From these general considerations, galvanised iron appears to be, roughly, about twice as well adapted for overhead lines as hard-drawn copper. But this proportion is not maintained when all the conditions of the problem are taken into consideration. In the first place, the greater bulk of the iron is objectionable on account of the expensive posts and attachments necessary to carry the weight; and secondly, iron, although galvanised, rusts, and has a shorter life than copper; and so the cost of maintenance is far greater than with copper or its alloys. Again, old iron wire has practically no marketable value, whereas copper is always saleable. As regards total prime cost of line it is not easy to say which metal is the cheaper for all cases, but generally for light work, such as telegraph and telephone lines, there is very little to choose between the two. With heavy power lines, however, copper will always work out the cheaper (unless the relative costs be very different from those assumed here), and the weight of the iron becomes practically prohibitive. And even with large copper cables of, say, 19 strands each of No. 16 S.W.G. (and larger) the supports have to be so frequent as to form a very important item in the cost of the *whole line*. In such cases it is usual to suspend the copper conductor from a small steel wire carried on insulators; by this means the spans can be materially lengthened, and the total cost largely decreased.

If, however, the conductor is insulated, copper is by far the cheaper metal, since the necessary bulk of insulation material is much less. The areas of the two metals are for equal resistance as 1 : 7, say, and the diameters will be as $\sqrt{1} : \sqrt{7}$, or $1 : 2{\cdot}63$; and for an equal thickness, t, of insulation, the volume of insulation material will be as $(1 + 2\,t)^2 - 1^2 : (2{\cdot}63 + 2\,t)^2 - 2{\cdot}63^2$. But since to maintain the insulation resistance constant per unit length of conductor it is necessary that the depth of the dielectric vary as the diameter of the conductor, the diameter of the iron wire over the insulation will have to be $2{\cdot}63 + 2\,t\,\frac{2{\cdot}63}{1} = 2{\cdot}63 + 5{\cdot}26\,t$. To illustrate the meaning of these ratios let the copper conductor be No. 10 S.W.G., and let $t = 0{\cdot}1$ inches. Then, the diameter of copper conductor = 0·128in., and the diameter over the insulation = 0·328in. The diameter of iron conductor = 0·336in., and the diameter over the insulation = 0·862in. Now the insulating materials generally used, such as pure rubber, vulcanised rubber, &c., are costly, and therefore the iron conductor is commercially impossible.

These comparisons have been made between iron and copper, because they are the metals most likely to be used for power circuits. The copper alloys, however, present many advantages and combine the high conductivity of copper with the tensile strength of the best iron. Bronze wires are in general use for telephones and telegraphs and will inevitably come into favour for transmitting power. Silicium bronze has a conductivity nearly as high as that of hard-drawn copper and a breaking strain of at least 90,000lb. to the square inch. Bearing in mind the relative weights for a given resistance, it is evident that the spans can be made longer with the bronze than with galvanised iron; in practice, it is found that they may be made about 50 per cent. longer, and less bulky and costly insulators are necessary. One reason why the copper alloys have not been used much as yet is a real or fancied difficulty in procuring a wire of a specified resistance and tensile strength, it being found that one of these qualities is frequently gained at the expense of the other. This difficulty is merely a detail of manufacture and will soon be overcome if it is not already so. The cost, about one shilling per lb., is high, but will be reduced as the demand for the alloys increases.

The figure of merit of silicium bronze as previously estimated for hard-drawn copper and iron is $\frac{1}{1{\cdot}7} \times \frac{1}{8{\cdot}7} \times \frac{1}{12} \times 90{,}000 = 508$.

It is better than copper by about 12 per cent. It should be noticed that the atmosphere has practically no effect upon most of the copper alloys, and that they are not so liable to crystallisation as hard-drawn copper. These qualities largely reduce the cost of line maintenance, and in conjunction with the other points already discussed render silicium bronze perhaps the best all-round metal for power lines.

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Underground Lines, Conduits, &c.

It is becoming generally recognised that aërial lines, whether of bare copper or insulated cable, though permissible in open country where they are free from wilful or accidental damage, are a source of possible danger in towns, &c. And it is also apparent that such lines are especially subject to interference from lightning. (The æsthetic view of the question is irrelevant to the purely engineering aspect, and need not be discussed.) It is evident, however, that if a line has to be made permanent, and be required to work continuously at a minimum cost of maintenance and depreciation, it must be protected from atmospheric influences and accidental injury. These ends are best attained by laying the cables in the earth. Experience gained with gas and water mains at once points to two methods: in one the cables are simply *buried in the soil* at a safe depth; in the other, they are *run in conduits or pipes.*

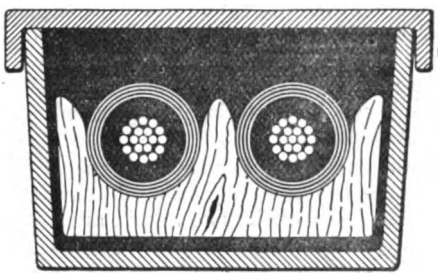

FIG 19.—Callender Solid Bitumen System. Cross Section of Trough.

If the first system be adopted, it is evident that the insulation of the cable must be protected from mechanical injury during laying, and afterwards from a possible erosive action of the soil, and, perhaps, from the effects of water. This suggests the use of a metallic sheathing of lead if the Water Company's practice be followed, or iron if the Gas Company's experience be accepted. Both kinds of armouring have been used with success here and failure there. The causes determining the result are often obscure, but electrolytic decomposition, assisted more or less by the peculiar constituents of the soil and water, can always be shown to have taken place. In fact, the problem is complicated by the inevitable leakage of at least one main, usually the negative, and sometimes by weak points on both of them. The passage of an electric current through water breaks up the chemical combination into its component gases, oxygen and hydrogen. The nascent oxygen immediately attacks any

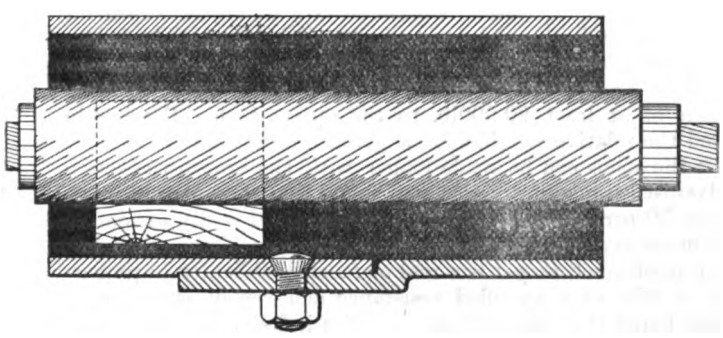

FIG. 20.—Callender Solid Bitumen System. Sectional Elevation of Trough.

oxydisable material in contact with it—the lead sheathing, for example—and soon changes its nature. Other more obscure chemical changes, resulting in the formation of free chlorine, hydrochloric, and sulphuric acids, and other corrosive agents, may also occur if the soil be impregnated with suitable salts. Hence, wherever there is a leakage of electricity, there is a tendency to destroy the metallic sheathing, the insulation, and, finally, the copper conductor itself. It is, therefore, necessary to protect the metallic armouring by servings of jute soaked in tar, ozokerite, or some preservative compound. And in all cases it is wise to lay the cables in fresh soil, clay, or fresh water gravel, and to protect them by boards from mechanical injury, such as an inadvertent blow from a pickaxe. The armoured concentric mains laid at Bradford for the lighting service are a good example of this class of work. They have been in continual use for about four years, and the author is assured by the engineer that the insulation resistance has increased since they were laid in the ground, and that no trouble is experienced with the coupling-up of consumers through the iron junction boxes already referred to.

The second method may be considered under two heads:—(*a*) the "built-in" systems, in which the cables, usually strips of bare copper, are laid in conduits, and covered-in permanently, so that they cannot be reached without taking up the top soil; and (*b*) the "drawing-in" systems, in which continuous lines of waterproof conduits or pipes or troughing are laid, with drawing-in boxes at intervals of from 80 to 100 yards in the straight, and at all sharp bends.

A complete discussion of these systems of laying cables is not necessary here, since they properly belong to a treatise on central station for distributing light (and perhaps power) over a large area to a number of points in close contiguity; whereas this book treats, primarily, of the transmission of power between places relatively far apart, and, secondarily, of its distribution

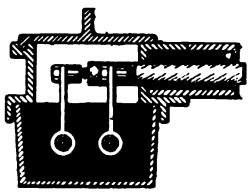

FIG. 21.—Callender Solid Bitumen System. Cross Section of Service Box.

to a comparatively few points in a limited area. And should it be deemed advisable to run the cables underground, some modification of the first method (cables simply buried) is sure to be selected from the mere consideration of first cost. If, however, the cables are likely to be frequently disturbed for coupling-up supply mains to new points, or if they are likely to be increased in number within a reasonable time from the first installation, then one of the second systems may prove to be the cheaper in the long run, but this contingency is improbable on the supposition laid down in the preface and introduction. It will be, therefore, sufficient to illustrate the methods by a few characteristic drawings.

(*a*) One of the best "built-in" systems is the Callender Solid Bitumen system (illustrated in Figs. 19 and 20). The troughs are made in cast iron, in lengths of 6ft. with sockets at one end, so that when fitted together there is a free "run" inside. The lengths are coupled together by counter-sunk bolts and

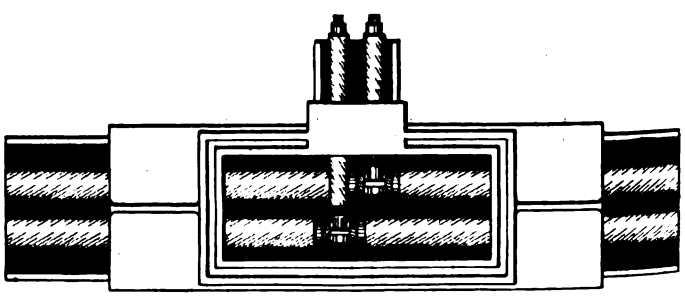

FIG. 22.—Callender Solid Bitumen System. Plan of Service Box.

nuts. Bends and circular pieces are used to carry the mains round corners and for changing the levels at crossings, but considerable deviation from the straight line is possible with the standard type. The method of laying is as follows:—The troughs are first connected in position and then a small quantity of molten bitumen is run in and before it sets bridges of bitumenised wood are placed in it at intervals of 18in. The insulated cables are next laid in position and held in place by these bridges so as to be clear of the sides and bottom of the trough and of each other. The interior space is then carefully filled up with bitumen to within half an inch of the top, and the whole is finished off by a covering of Portland cement or cast iron lids. It is obvious that cables laid in this manner are completely protected from the action of damp, water, or

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gases, and repairs can be easily and rapidly made. The method of coupling up the service mains is illustrated in Figs. 21 and 22.

(*b*) The drawing-in systems are illustrated by Figs. 23, which refers to the Callender-Webber systems and shows the conduit, a brick pit and method of coupling the feeders or service mains without junction boxes. The conduits consists of

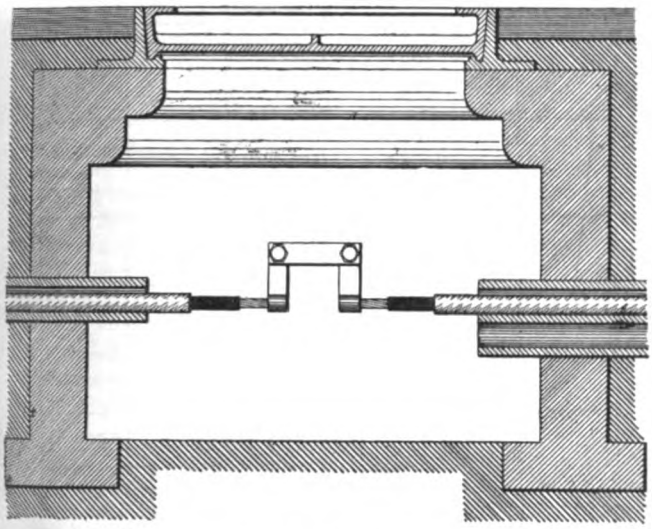

Fig. 23.—Callender-Webber Drawing-in System. Section of Manhole.

bitumen concrete formed in blocks 6ft. in length and pierced by "ways" (*see* Fig. 24). The standard sizes of these cases are for 2, 3, 4, and 6 ways of either 1½in., 2in., 2⅜in. or 3in. in diameter. To join the lengths, the cases are brought together and an iron mandril placed in each of the ways. Melted bituminous concrete is then run between the two cases and rammed home. When the bitumen is cool the mandrils are withdrawn leaving

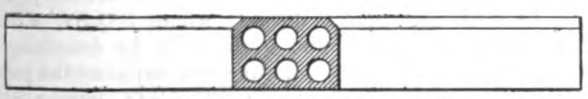

Fig. 24.—Callender-Webber Conduit.

a perfect joint as strong as the main case itself, The "ways" are quite smooth throughout their entire length, but it sometimes happens that the cables sink into the bitumen in course of time and, therefore, cannot be withdrawn. The Callender-Raworth system (Fig. 25) is designed to obviate this difficulty and combines the mechanical strength of the solid bitumen system with the facilities of a drawing-in system. It consists of cast iron troughs with flanges. The spaced wooden bridges

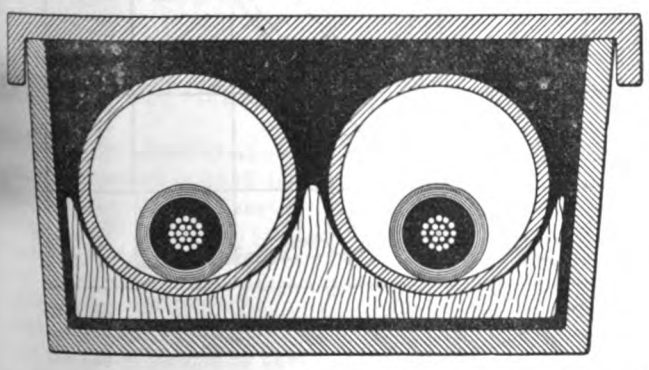

Fig. 25.—Callender-Raworth Drawing-in System. Cross Section of Trough.

are fixed at short intervals, and on these are laid tubes of specially made paper impregnated with bitumen. The tubes are joined together by sleeve pieces and are then buried in solid bitumen. The conduit is closed on the top by a cast iron lid with flanges fitting over the sides of the trough. The lighting mains now being laid at Huddersfield are on this principle.

(To be continued.)

INDUCTIVE CIRCUITS.

BY W. E. SUMPNER, D.SC.

Although much has been written concerning the action of combinations of coils and condensers when used with alternating currents, the quantities, such as self-induction, capacity, &c., which determine the behaviour of these conductors, have only been referred to in a general way, and their relative values for such cases as are liable to occur in practice have, as far as I am aware, never been actually indicated. The usual thing has been to choose values for these quantities, to work out the results numerically, and to assume that the curves representing these special cases give a correct idea of the effects which actually occur. The values chosen, however, have, as a rule, been such as could obtain only in very exceptional circumstances; and it may, therefore, be of some interest to reproduce here some curves, which I drew out for myself two or three years ago, and which serve to show how the effects vary with different relative values of the inductance, capacity, resistance, &c., of the various parts of the circuit.

Considering first the case of a coil and condenser in series, subjected to an alternating pressure of V volts, it has been frequently shown that the current A in amperes is related to V by the equation

$$A = \frac{V}{\sqrt{R^2 + \left(Lp - \frac{1}{Kp}\right)^2}} \quad . \quad . \quad . \quad (1)$$

where R is the resistance of the coil in ohms, L its self-induction in secohms, K the capacity of the condenser in farads, and where p is the quantity

$$p = 2\pi n$$

in which n is the frequency of the current in periods per second.

The quantities Lp and $1/Kp$ are each measurable in ohms, the former being called the "inductance" of the coil, and the latter the "inductance" of the condenser. It follows from equation (1) that the voltage required to produce a given current A amperes is proportional to

$$\sqrt{R^2 + \left(Lp - \frac{1}{Kp}\right)^2}$$

or to the hypothenuse of a right-angled triangle, one of whose sides represents R, and the other the inductance $Lp - 1/Kp$. If, therefore, in Fig. 1, we set off a vertical distance O A equal to R, and a horizontal distance O L equal to $Lp - 1/Kp$, the length L A will represent the voltage needed to produce the given current; and thus, if we set off an ordinate L a at L equal to L A, and repeat this operation for different positions of the point L along the horizontal axis, we get a curve A a, the ordinate of which represents the voltage needed to produce the given current, while the abscissa, reckoned from the point O, represents the value of the inductance $Lp - 1/Kp$. The curve A a thus shows the effect of varying the self-induction of the coil, if the capacity of the condenser and the frequency of the current remain constant. If O K is equal to $1/Kp$, the inductance of the condenser, and if K L is equal to Lp, the inductance of the coil, then O L is equal to $Lp - 1/Kp$, and the voltage needed to make a current A amperes flow through the coil is L a. If K L is greater than K O this voltage gradually diminishes as the self-induction is decreased until $Lp = 1/Kp$, when the voltage is equal to O A. As the self-induction is further diminished the voltage increases, and continues to increase till L is nothing, in which case the ordinate at the point K represents the voltage. Five curves have been drawn in Fig. 1 corresponding with various values of the resistance R. These curves are A a, B *b*, C *c*, D *d*, and E *e*. The method of construction is in all cases the same, and is sufficiently indicated by the equations L A = L a, L B = L *b*, &c., and L E = L *e*. In Fig. 1 the distance O K, representing the inductance of the condenser, is supposed to be 20 ohms. This means that if 100 volts are applied to the condenser terminals a current of 5 amperes will pass through the condenser. The resistance of the conductor is supposed to be 2 ohms for the curve A a, 5 ohms for B *b*. 10 ohms for C *c*, 20 ohms for D *d*, and 30 ohms for E *e*,

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In order to judge which of these curves most nearly represents a usual state of things, it is instructive to compare the ratio of O K to the lengths O A, O B, &c. The length O K is the inductance of the condenser; but it is also the value of Lp, the inductance of the coil, for which the voltage needed to produce a given current is a minimum. But if R is the resistance of the coil, the ratio of Lp to R is the tangent of the angle of lag of the current in the coil behind the voltage at its terminals, and this ratio is never large. Indeed it is exceptional to have Lp as large as R. With ordinary transformers, even when the secondaries are open-circuited, the value of Lp is rarely greater than R, while if the secondary is closed it is much less. With alternating current motors the ratio may sometimes be greater than unity when the load is light; and with choking coils the ratio is sometimes considerably greater. Circumstances must, however, be exceptional, if this ratio is greater than two, although a case in which the ratio is 5 sometimes occurs, and even ratios of from 10 to 15 are possible with alternating currents of ordinary frequencies. The latter cases occur with conductors having very small power factors, such as a hedgehog transformer when on open circuit. Probably the most striking case of this kind happens when one alternator drives another as a synchronous motor, the electromotive forces of the machines being very different from one another. But this is a case of such little practical interest that it need not be considered. We conclude, therefore, that the

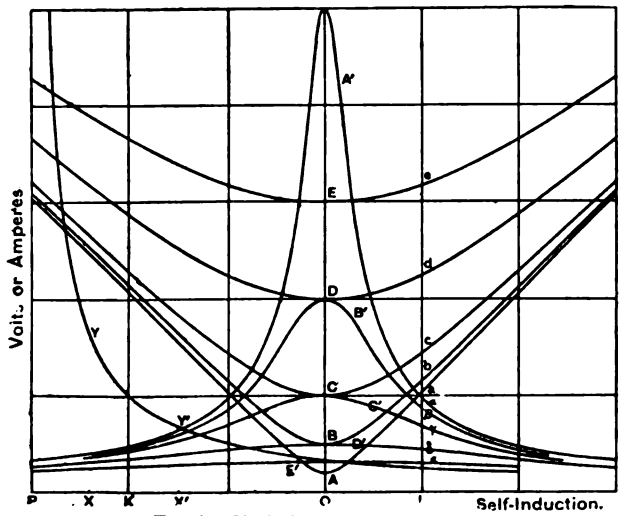

FIG. 1.—Variation of Self-Induction.

curves in Fig. 1, which represent conditions easily realisable in practice are those for which Lp/R is less than 2. Now this ratio is the ratio of O K to the ordinate of the curve at O. This ratio is 10 for curve A a, 5 for curve B b, 2 for curve C c, 1 for curve D d, and 0·66 for curve E e. The two latter curves are thus the ones which can be easiest produced experimentally, while the three former represent more or less unusual cases.

It is instructive to compare with these curves, the ordinates of which represent the voltage needed to produce a given current, a corresponding set of curves representing the current produced by the application of a given voltage to the circuit. If we draw a rectangular hyperbola Y Y′ (such that the product of ordinate and abscissa is constant all along the curve, thus P X. X Y = P X′. X′ Y′) we can easily get the second set of curves from the first. Take any ordinate, say L c, of one of the curves. Project c horizontally on to the curve Y Y′, and the abscissa of this point on Y Y′ is the ordinate, L γ, of the new curve. In this way the curve A′ α is got from A a, B′ β from B b, C′ γ from C c, D′ δ from D d, and E′ ϵ from E e. As before, the curves E′ ϵ, D′ δ represent usual cases, while C′ γ, B′ β, and A′ α represent exceptional ones. It will be noticed, therefore, that although the current rises to a maximum and then diminishes as the self-induction of the coil is continuously increased, the proportional rise is not so very large under conditions such as are likely to occur. The ratio of the maximum current to the current when the self-induction is *nil* is 10·5 for A′ α, 4·3 for B′ β, 2·3 for C′ γ, 1·43 for D′ δ, and 1·22 for E′ ϵ.

The effects produced by altering the capacity of the condenser, or the frequency of the current, can be traced out in a similar manner, and the results obtained are exhibited in Figs. 2 and 3.

In Fig. 2 the lengths O A, O B, &c., represent the resistances taken for the coil. The length S O represents to the same scale the quantity Lp, now to be considered constant. The

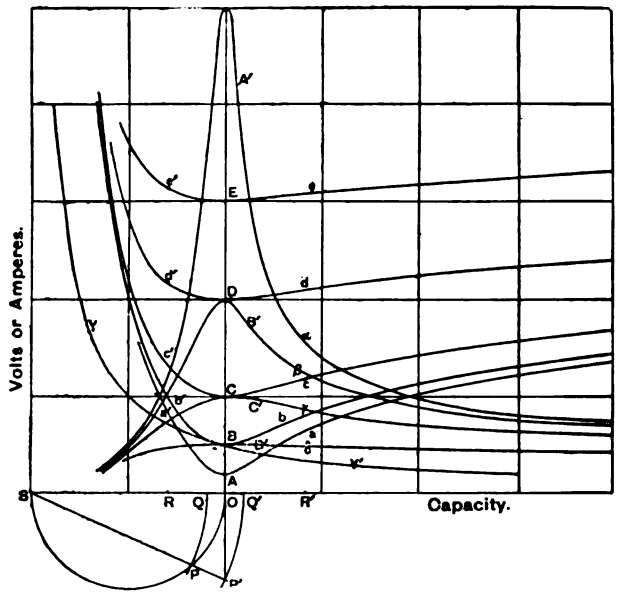

FIG. 2.—Variation of Capacity.

capacity of the condenser is represented by the horizontal distance measured from S, such as S Q′, the scale for capacity being so chosen that when $K L p^2 = 1$ the length S O represents the corresponding value of K. Then for any value, S Q′ for the capacity K, the inductance $1/Kp$ must be inversely proportional to S Q′ and must be S Q where S Q. S Q′ = S O². The point Q can easily be found graphically by describing a semi-circle on S O as diameter, finding by compasses the point P′ on the vertical from O, for which S P′ = S Q′, joining S P′, cutting the circle in P, and finding Q such that S P = S Q.

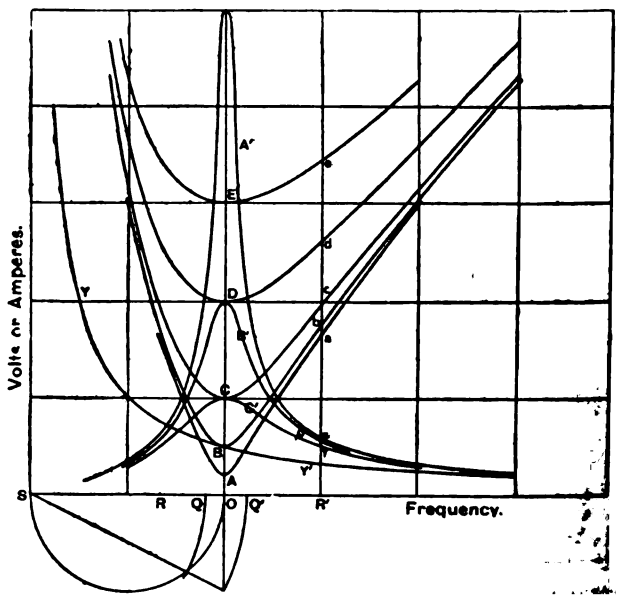

FIG. 3.—Variation of Frequency.

Similarly, the point R corresponding with any values S R′ of the capacity can be easily found. Now S O is the inductance of the coil, or Lp, while S R is the inductance, $1/Kp$, of the condenser when the capacity is represented by S R′. So that R O is equal to the difference $Lp - 1/Kp$ of the two inductances. It follows that if O A is the resistance of the coil, the length R A represents the voltage needed to make a given current

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flow through the conductors when the capacity is equal to S R', at R' therefore set off an ordinate S a equal in length to R A. Similarly at R set off an ordinate R a' equal to S R, for this can be shown to be the voltage needed to produce the current when the capacity is equal to S R. In this way the curves a' A a, b'B b, c'C c, d'D d, e'E e, can be all drawn; and the corresponding curves denoting the currents produced in the circuit by the application of a constant voltage can be deduced by the same process as in Fig. 1. The lengths O A, O B, &c., denoting the resistances in these curves are the same as those in Fig. 1, and the inductance S O in Fig. 2 is the same as O K in Fig. 1, so that the same remarks apply to the curves in Fig. 2 as were made above with reference to the curves denoted by the same letters in Fig. 1.

In Fig. 3, which exhibits the effect of varying the period, the frequency is plotted to such a scale that, when the current frequency is such that $K L p^2 = 1$, the length S O represents this particular frequency, and also the value of $L p$ at this frequency. The lengths O A, O B, &c., representing the resistance of the coil, are plotted to the same scale of resistance as the inductance $L p$. As before, find a series of points Q Q', R R', &c., such that $S Q . S Q' = S R . S R' = S O^2$. Then, when the frequency is represented by S Q', the inductance of the coil $L p$ will also be represented by S Q', while the inductance $1/K p$ of the condenser will be denoted by S Q. The length Q Q' will represent $L p - 1/K p$ the inductance of the circuit, and the voltage necessary to send a given current will be represented by the hypothenuse of a right-angled triangle, one of whose sides is Q Q' and the other is O A for the curve A a, O B for the curve B b, &c., &c. The way to draw the curves A a, B b, &c., is thus pretty obvious, and the reciprocal curves showing the current produced by a given voltage can be obtained as in the other cases. It will be noticed in all these curves, shown in Figs. 1, 2, and 3, that the current changes very rapidly in the neighbourhood of the line O E for the curves A'α and B'β, even for the slightest alteration of the variable denoted by the abscissa of the curve (self-induction capacity or frequency, according to the case considered), but this is not the case at all with the curves C'γ, D'δ, or E'ϵ, which alone represent circumstances such as may easily arise.

We have only considered the case of a coil and condenser when connected in series. It is obvious that when the coil and condenser are put in parallel the results will be similar. As a matter of fact, the curves shown in the diagrams will represent *exactly* what takes place, only the curves A'α, B'β, C'γ, D'δ, E'ϵ, instead of denoting the current produced by a given voltage, will now represent the voltage needed for a given current in the main circuit, while the curves A a, B b, C c, D d, E e, will represent the current produced by applying a given voltage. The lengths O A, O B, &c., which formerly denoted the resistance of the coil, will now denote the reciprocal of that quantity.

THE ELECTRIC LIGHTING OF BRUNN THEATRE.

One of the oldest Continental electric light plants is that which was started in 1882 by the Société Electrique Edison de Paris, at the Brünn Theatre. After a run of eleven years, during which the old-type machinery seems to have done remarkably well and to have suffered little depreciation, this plant is now about to be taken over by the municipality. This theatre claims the distinction of never having had a single gas jet burning within its walls; and is probably one of the first—if not the first—theatre to have been electrically lit, so that a few details of the plant which have been sent us by Mr. Francis Jehl, who superintended its erection, may prove of interest to our readers.

The dynamos are of the old Edison "K" type, having three parallel magnets, each machine giving an output of 20 kilowatts. There are four of these machines, and only one of them has an entirely different commutator from that with which it started life. The other commutators have held out through no less than 3,300 performances; and only once during this time has an electrical breakdown occurred. This isolated failure of the plant was, moreover, due to the bursting of a water-pipe. It may be mentioned that the Edison Company had contracted to supply the light, subject to a fine of 300fl. for each breakdown. The steam engine is capable of developing 110 H.P., and is of the twin-cylinder non-condensing type. It is supplied with steam from three Dupuis boilers.

The theatre contains 1,446 16 c.p. glow lamps, 5 regulating arc lamps, and 1 hand-fed arc lamp. Besides these, there are various other lamps for stage effects and a 4 H.P. electromotor. The average daily consumption is about 46·5 kilowatts during the time of the performance, which amounts to about 100,800 E.H.P. hours per annum. During 1892 the total cost of production, including salaries, wages, &c., amounted to £964, or about 104 E.H.P. hours per £1, or 2½d. per E.H.P. hour.

TRAMWAY MOTORS.*

One of the points to be considered in connection with tramway motors is a compact design adapted for the limited space under the floor of the car. With wheels of about 30in. diameter, and the condition that the lowest point of the mechanism must clear the ground by at least 3in., this is a difficult problem. All parts must be easily accessible and capable of being exchanged, whilst small weight and large power are essential. The author illustrates six different types of motors and gear made by the Edison Company, the Thomson-Houston Company, the Short Electrical Railway Company, and the Oerlikon Works. The power of these motors, as stated in a table, varies from 12 to 17 H.P., and the weight from it is 0·75 to 0·9 of a ton. The general practice at present is to have simple reduction gear 1 to 4 or 1 to 5, and an armature speed of 400 or 500 revolutions per minute, and two motors per car, one on each axle. The loss of power in the gear is from 4 to 6 per cent. The author does not advocate gearless motors. Reckenzaun's worm gearing is stated to be as efficient as double-reduction gear. The following table gives the efficiency at full load for different methods of gearing:—

Gearing.	Armature speed.	Efficiency, per cent.	
		Total.	Motor only.
Double-reduction	1,100	60—65	75—85
Worm and wheel	1,200	65—68	75—85
Single-reduction	450	80—83	85—88
Gearless	110	82—85	82—85

The motors are series-wound, and may be coupled in series or in parallel. With the former arrangement the total E.M.F. (usually 500 volts) is divided between the two motors, but in case of one pair of wheels skidding the available power is reduced in both motors.

With the parallel arrangement this defect is absent, but to get the power evenly divided between the two motors the current must be split, not through the armatures only, but also through the field, which necessitates the employment of two reversing switches. A very important point is the regulation of speed and power for which two methods are available: (*a*) by resistances in the main circuit, and (*b*) by sub-dividing of field coils. The first method is the simpler, but the construction of the rheostats presents considerable difficulties, owing to the limited space within which they must be housed. There is also waste of power, which is avoided under the second method, but the latter necessitates the employment of a very complicated switch and connections. The author recommends the employment of an ironclad type of field to avoid magnetic leakage, and give mechanical protection to the armature. There is with external poles the danger that pieces of iron lying on the roadway may be picked up and get into the armature. Whether the field should be bipolar or multipolar is still an open question.

Handbook for Engineering Visitors to America.—The "Committee on Information and Courtesy" of the American Society of Civil Engineers have prepared a neat handbook for the information of foreign engineering visitors during the Exhibition. It contains a map of the United States and list of public works, railroads, mines, and manufacturing establishments, which might be of interest to visitors.

* By E. Kolben. Abstract from Foreign Abstracts of *Proc.* Inst. C.E., Vol. CXII.

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(The Oldest Electrical Journal.)

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny

Editorial, Publishing, and Printing Offices:

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.

Telephone No. 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co.*"

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"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. It is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices.*

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GRAVITY AND THE ETHER.

The attitude of awe with which we have hitherto regarded the ether is intensified by the further proposition as to its complicated simplicity, so to speak, which is made in a letter by Prof. LODGE this week. The latest property with which this well-burdened medium is to be invested is really a *pair* of properties: a pair, so nicely balanced, so delicately opposed, that the effect of the one is completely annihilated by the effect of the other. One thing is certain, that the existence of two such mutually cancelling effects can never be proved, disproved, or even detected; for we can only know of anything in so far as we can perceive it, and we can only perceive it in so far as it is allowed to do something. Permanent equilibrium implies eternal unknowableness. Electrical theory has been making no less rapid strides than electrical practice, and the day is surely approaching when we shall be able, if not to answer the question, "What is electricity?" at all events to give as rational an answer as can to-day be given to the question, "What is sound?" Little more is to be expected from purely electrical research unless by revealing something of the nature of ether. Every step towards our knowledge of this medium is of the greatest interest to the student of electricity, and even if the consideration of Dr. LODGE's suggestion leads us wide of electrical science, we pursue it in the hope that it may guide us to an intelligible theory.

One of the properties assumed by Dr. LODGE is the viscous retardation of matter moving through the ether; the other is the finite rate of propagation of gravitational stress through the same medium. The one of these exerts a retarding force on a moving planet, the other an accelerating force; and it is assumed that the conditions are always and everywhere such that the algebraic sum of their moments around the centre of the system shall be constantly equal to zero. The requirements are nothing short of stupendous; and our admiration of the ether must go up by leaps and bounds as we learn more and more of its resourcefulness. But—and this is an important element of doubt—we are not quite satisfied that

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any consistent mathematical theory can be based upon the hypothesis. We must, of course, assume that the law of aberration and the law of retardation due to viscosity are invariable in every part of a moving material system; the same, say, at the orbit of Neptune as at the orbit of Mercury. Yet, if we make these necessary assumptions, we find it very difficult to determine the law of variation of the two effects with change of velocity and radius vector. How, for example, shall we reconcile the proposed explanation with Bode's law? Prof. Lodge proposes that the viscous force shall be directly proportional to the velocity of the planet through the ether. The moment of this force would, therefore, on an average, be equal to the product of the mean velocity into the mean radius. But the moment of the accelerating force due to gravitational aberration would vary in another manner, namely, with the product of the mass of the planet into the mass of the central attracting body and the velocity of revolution of the one round the other. It, therefore, the two moments are to cancel out in every case, it can only be by giving to a system of planets a set of periodicities which shall bear quite a different relation to their distances from the centre to that settled by what is generally known as Bode's law. Again, it is difficult to see how there could be equilibrium of the two moments both at the perihelion of the planet, when it is beginning to be retarded by gravity, and at the aphelion, when it is beginning to be positively accelerated. Lastly, since it is evident that the rotation of all the planets must exert an aberration moment on the sun, while it is quite inconceivable on any hypothesis that this is balanced by the solar friction against the ether, it is a matter for surprise that not the slightest elliptic movement or degree of wobbling is apparent in the sun's motion. After so many millions of years one would expect to find some evidence of this continuous want of equilibrium. In fact, while we should like very much indeed for the ether to have these remarkably antagonistic properties, we are not quite prepared to see that it really can have them.

Apart altogether from the direct consequences of attributing viscosity and an aberration of 20sec. to the ether which transmits gravity, and making this ether identical with that which transmits light, we must not lose sight of the many other duties which are imposed upon this ether, nor of the necessity for introducing some sort of harmony among the properties with which it is to be endowed. The earliest of the duties imposed on the ether, and the one which led to the suspicion of the existence of this substance, was that of conveying light waves. Since then it has had to undertake many an additional arduous duty. Matter of all kinds has been conceived to be nothing but a collection of complicated and highly-differentiated ether vortices, and all the properties which matter possesses have been attributed to the various interactions of those same vortices. The electric current, if not considered to be one and the same thing as ether, is assumed to be so closely associated with ether that the distinction becomes almost metaphysically fine. Electric charges and ether stresses have long been shown to be identical. Magnetism, on every rational hypothesis which has yet been put forward, implies a modification of the ether in and around the magnetised body. And the phenomenon of electromagnetic induction, as well as of ordinary magnetic induction across any intervening space, is explained on the assumption of the setting up of disturbances in the ether in that space, disturbances which continue to be emitted as long as any change continues in the state of the inducing body. In fact, all the phenomena of electrostatics and electromagnetics, of matter and of force, have, with the two exceptions of gravitation and the mysterious function called life, been directly referred to the properties of one and the same ether for their ultimate explanation. And, now it is shown that there is no inherent objection to the ether being burdened with gravitation also; it has been shown by Mr. Oliver Heaviside that gravity may be explained by means of waves propagated in an elastic ether, and by Prof. Lodge that this ether need not be any different from the ether which does all the rest of the work. But the suggestion is made only at the expense of some properties which hitherto the ether has been asserted to possess, notably, its perfect elasticity. If we impart to the ether such a degree of viscosity as will altogether swamp out the aberration at the speed of the earth, we have to account for a very considerable absorption of the rotational energy of the sun into the ether itself. We may, of course, accept the hypothesis of M. Hirn, that energy dissipated in the ether of remote space is employed in the construction of fresh atoms of matter out of plain ether; and thus account for the energy when it is gone. But there still remains the problem as to the extent to which such a large additional rate of dissipation of solar rotational energy, besides that accounted for by tidal action, must modify our views as to the remote history of the solar system and reduce our calculations as to the age of the sun. The whole question is, in short, extremely complicated, and we cannot see that Dr. Lodge's suggestion makes for simplicity. Nevertheless, we need not despair of reducing this chaotic mass of incompatibilities and incongruities to something like order, even though the knot may require a second Newton to unravel it.

OBITUARY.

SAMUEL EDMUND PHILLIPS.

It is with deep regret that we announce the death, at the age of 45, of Mr. Samuel E. Phillips, of the well-known firm of Messrs. Johnson and Phillips, which took place on the 22nd inst. at his residence at Shooter's Hill, in Kent. As may be known to many of our readers, Mr. Phillips has been in failing health for some years, and has of late taken no active part in the business of the firm.

When a boy, Mr. Phillips was brought into contact with telegraphy, his father being at that time engaged with Dr. Whitehouse in carrying out experimental work in connection with the first Atlantic cable. He subsequently accompanied his father in the first Malta and Alexandria cable expedition, after which he became a member of the staff which Colonel Stewart formed to go out with the Persian Gulf cable, remaining at Bushire as a junior clerk. At the end of three years' service he returned to England, and obtained an appointment on the electrical staff of Messrs. Latimer Clark, Forde, and Co., leaving these gentlemen to become electrician to Mr. W. T. Henley, in whose service he remained for ten years. At Mr. Henley's works he was appointed manager of the cable department, and occasionally he accompanied some of the cable expeditions as the head of the electrical department. As an inventor, Mr. Phillips has given us a fluid insulator, which has been largely adopted in India, Egypt and other countries, and has proved of immense value for overhead lines for telegraphy, electric lighting, and power transmission. In 1875 he joined Mr. W. Claude Johnson in partnership, and a small works was established at Charlton. This formed the nucleus of the present extensive range of factories.

Mr. Phillips took the keenest interest in scientific matters generally, and to his good judgment and sound common sense may be attributed in a great measure the success of his undertakings. His genial manner and generous nature made him a universal favourite, and his loss will be deplored by a very wide circle of friends and acquaintances.

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THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 315.)

The crucibles being placed in position in the furnace, the door is lowered into its position, and cemented round the edge with fire-clay. The pyrometer is then inserted through the hole and is also cemented round where it passes through the door. The fire is then lighted, and by means of the damper is kept very low at first; eight hours at least should be allowed for traversing the range of temperature covered by the pyrometer. The first six or seven hours of this time may be in daylight, but by the time that the highest reading on the pyrometer is reached it should be dark, as the regulation from this point will have to be done by eye. The eye is, of course, much better able to judge of colour (temperature) after dark than in daylight, when, indeed, the first dull red heat could not be distinguished at all. The highest temperature indicated by the pyrometer having been reached, the instrument is withdrawn and the peep-hole stopped with the fire-clay plug. It will be necessary from this time to watch the temperature through this hole, the plug being withdrawn from time to time for the purpose. Another five or six hours should be occupied in bringing the temperature gradually up to a bright red heat, and when this is reached the full power of the furnace may be applied, and three or four hours more will be occupied in bringing the temperature up to a white heat. The temperature which can be attained by a furnace of this kind is so great that the best fire-bricks will begin to run. Having raised the temperature to the highest point, there is probably not much advantage gained in maintaining it for any length of time. The fire may, therefore, be allowed to die out and the furnace cool down. This again must be done gradually, not on account of danger to the filaments, but to the furnace. The furnace-door and the fire-door must be kept closed. Rapid cooling will have a very deleterious effect on the furnace, which will require re-building much sooner than it otherwise would do. Twelve hours at least should be allowed for cooling. The crucibles should not be disturbed until they are cool enough to be taken hold of by the hand. If they are handled while too hot, they are likely to be bumped about and the filaments damaged. The wear and tear on a furnace which is used in this way, alternately heated and cooled, is much greater than that on a furnace, such as a glass furnace, which is kept constantly going at one temperature. If heated and cooled off every two days, it will require re-building probably every six months. When the crucibles are cool they are withdrawn and placed on a truck and wheeled to the room where they are to be unpacked.

Having got the crucibles safely from the furnace to the bench where they are to be unpacked, the first thing to be done is to remove the lids. This can usually be accomplished without difficulty, though it is sometimes necessary to use a good deal of force, owing to the lid having become fused in places to the crucible. Care must be taken that the crucible is not knocked or jolted about. The lid being off, it will first be noticed that the powdered carbon considerably has sunk, the space between the carbon box and the crucible being no longer full as it was when the lid was put on. This subsidence is due to the air which was originally imprisoned by the carbon having been driven out and not to any loss of the carbon by burning or otherwise. If through insufficient luting of the lid some of the carbon powder has been burnt, it will be at once apparent by a brown or yellow powder upon the top, which is the ash always left by the wood charcoal such as is used. No ash, however, is usually seen, and no carbon dust has been burnt.

It must be borne in mind that the filaments now in the crucibles are very different things from what they were when put in. They are now very brittle and easily broken. Consider for a moment the condition in which they now are and it will be understood that great care must be used in handling.

* Abstract from a book to be published shortly by *The Electrician* Printing and Publishing Company (Limited). All rights of re-publication reserved.

The parchmentised thread and the wooden sticks between the two parts of the carbon block are now carbonised and have shrunk, so that the top or larger piece of the block has sunk down upon the lower part. The parchmentised thread, now carbon, is still in one length wound round and round the carbon block. It is, therefore, evident that it will not do to lift out the block in the reverse manner to that by which it was put in. If this is done, the top or larger block being lifted out, the filaments will probably not have the strength to raise the lower one, which will remain at the bottom of the box, having broken through all the filaments. This would not matter if they were all to break at the lower end. It is, however, an invariable rule with filaments to break at a point which will render them useless. The sliding carbon partitions, however, provide an easy method of safely withdrawing the blocks. The carbon box is lifted out of the crucible and is gently turned on its end, the lid having been first removed. Each block of filaments then rests on one of the thin carbon plates. These are then carefully withdrawn one by one with the blocks of filaments lying flat upon them. The next thing to be done is to get the filaments off the blocks. Great care must be taken in handling the blocks at this stage, because the two parts are only held together by the filaments themselves, the wooden sticks, which originally fitted tightly into the carbon blocks, having shrunk during the carbonisation so as to become quite loose in the holes and no longer serve to hold the two parts together. If the blocks were wrapped in paper or calico the now carbonised wrapping must be undone. This is easily accomplished by cutting it along the edge of the block with a knife, when it can be turned back and the filaments exposed to view. With a pair of scissors the upper side of all the filaments may now be cut across between the two parts of the carbon block. Then with a knife the lower side of the filaments may be cut downwards against the carbon plate upon which they are lying. The round end piece of the block can, therefore, be removed with the tail ends of the filaments. The large part of the block can now be lifted up with all the filaments hanging upon it. They should be perfectly straight, and if they have been skilfully handled there will often be not so much as a single breakage. They may now be tipped off the block into a suitable tray or box and put away until wanted. They must, however, be kept in a perfectly dry place or air-tight box if they are to be kept for any length of time, as they may absorb moisture, with the result that when they come to be heated by a current of electricity they may break, or pieces may chip off, owing to the sudden generation of minute quantities of steam. If filaments are allowed to get into this state the moisture may be removed safely by slowly baking them at a temperature less than red heat. Looped filaments are taken off the blocks in a similar way. The filaments are cut midway between the loops and are then gently pulled off the carbon blocks. There is no difficulty in unpacking flat filaments carbonised between paper or calico. Spiral and other forms carbonised loose in powdered charcoal are more difficult to withdraw without breakage.

The process of joining the carbon filament to the leading-in wires (the wires which support the filament and convey the current of electricity through the glass) is usually called "mounting." It may be carried out in a variety of ways, some of which will now be described.

Platinum wire is always used to carry the current of electricity through the glass bulb to the filament. Platinum is employed because it has a coefficient of expansion nearly the same as that of the glass which is used, and because it will stand the necessary heating in the blowpipe flame without melting or oxydising during the process of "sealing-in." Other metals having a different coefficient of expansion will not do, as the glass will crack at the seal. Various means have been tried to obviate the use of platinum on account of its expense. Several experimenters have claimed to have produced alloys of other metals which may be used as a substitute for platinum. Alloys having about the same coefficient of expansion as glass can undoubtedly be produced, but they are open to the objection that they are unable to stand the temperature of melting glass or the action of the blowpipe flame without

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melting or burning, so that even if the glass does not crack there is likely to be a leak from the imperfect fusing of the glass to the wire. In order to make a safe seal it is consequently necessary to make a very long one, and extra time and trouble are required. No such method is likely to supersede platinum, as the supply of this metal appears to increase with the demand. The high price to which it rose a few years ago was not maintained, and it seems likely to continue to fall. It takes only a small amount of extra labour and a few failures to cost as much as the very small amount of platinum which is really necessary. If a cheap alloy could be produced, which could be used in exactly the same way as platinum is now used, it would, no doubt, very soon take the place of that metal altogether, but it is a question if any substitute requiring a more elaborate seal will be able to do so. The platinum need only enter the lamp for a short distance. If it is desired that the filament be placed some distance away from the seal, copper wires may be fused to the platinum and the filament joined to the copper. Thin copper and platinum wires may be easily fused together. The ends of the wires are held in a small pointed blowpipe flame. The copper quickly melts and a small bead is formed. While this bead is liquid the hot end of the platinum wire is stuck into it and both are removed from the flame when it is found that they are firmly united. If the wire within the bulb is required to be of some length it will be necessary that it be supported, or the weight of the filament may cause it to bend over. It is easy to stiffen the wires by glass. A coating of glass may be fused on the wires, or a T piece of glass may be used, so that the ends of the crosspiece support the wires, the tail of the T being fused to the bottom of the bulb.

The joint between the leading-in wires and the filament may be simply a mechanical one, the filament being clamped in some way to the wires. A socket may be formed on the ends of the wires and the filament inserted and the socket squeezed tightly upon the filament. If the filament be flat it may be held to the flattened ends of the wires by a small bolt and nut. A split holder, with a ring on it exactly like a small crayon-holder, such as is used by artists, may be used. In each of these methods the filament is held simply by mechanical pressure. All these methods, which were used in the early days of lamp-making have, however, been abandoned as unsatisfactory or too costly. The filaments were apt to work loose, owing to the expansion and contraction with temperature. In the earlier forms of the Lane-Fox lamp a hollow carbon tube was used, into which the platinum wire was inserted at one end and the filament at the other, with some kind of carbon paste to make the joint firm.

(To be continued.)

ECONOMY IN WORKING VENTILATING FANS.

At a recent meeting of the Society of Chemical Industry a Paper was read by Mr. H. G. Watel on "The Application of Air in Motion to Chemical Industry," in which the utility of electrically propelled fans, and the questions of speed and size, were discussed. By what practically amounted to a rough application of the economic law the author arrived at the conclusion that slow speeds are preferable to quick speeds, notwithstanding that for the former a more costly fan will be necessary for any given draught of air.

"Many buy fans because they are a few pounds or shillings cheaper than others, and think that they have made a good bargain and saved money, without the slightest thought that in moving such a mobile and compressible matter as air there are all sorts of considerations, such as the slip of the air in the fan, and that the cost of the fan is a small matter compared with the cost of the power expended in driving it. For instance, a fan costs £25 and takes 2½ H.P. to drive it with a duty of 30,000 cubic feet of air per minute. Another fan costs, say, £20, displaces the same amount of air in the same time, but takes 3 H.P. to drive it. As every horse-power costs from £10 to £40 per annum, according to the size of the engine producing it, whether it is one of 40 H.P. or of 4 H.P., say an average of £25 per annum, then the additional half horse-power costing £12. 10s. being added to the cost of the fan, makes the relative expense even at the end of the first year £87. 10s. for the fan which originally cost the most money, and £95 for the cheaper fan, which will in addition be wasting continually £12. 10s. per annum in every successive year, even if it can move the volume of air or do the work. If I emphasise this by saying that I have tested fans of the same dimension, where one took not only 3 H.P., but nearly 12 H.P., to drive it, instead of the 2½ H.P. of which I have just spoken, it will at once be seen that the cost of the "cheaper" fan at the end of the first year would amount to £300, as against the cost up to the same period of its "dearer" rival of £87. 10s., and all to try to save £5 in tangible cash. There is also another point here to which I wish to draw your attention, which is, that if you can displace 15,000 cubic ft. of air per minute for 1 H.P. you are doing excellent work, and that fans professing to do nearly this amount of work per man-power, or, say, 150,000 cubic feet per horse-power, will, when you come to test them scientifically, not do what you may have expected of them. It always costs much more to move the same volume of air at a high velocity than at a low one; 1½ H.P. expended on a 36in. fan costing, say, £17 will move 14,000 cubic feet of air per minute; 1½ H.P. expended on a 60in. fan costing £37 will move 21,000 cubic feet of air per minute. At the end of the first year, still taking the horse-power at £25 per annum, the 36in. fan will have cost £54. 10s., and the 60in. fan will have cost £74. 10s. With the smaller fan each 1,000 cubic feet of air per minute will have cost £3. 17s. 10d., with the larger one the 1,000ft. of air will have cost £3. 16s. 9d., and every following year half as much air again will be displaced without extra cost, and, therefore, with corresponding economy. Therefore, it is at once apparent that it is generally a false economy to employ a small fan driven at a high-speed; on the contrary (except for special purposes where some amount of pressure is necessary), or to drive any faster than is needful for the purpose to be attained. This is due to the fact that air at double the pressure takes twice the power to move it, and more, and at three times the pressure it takes three times the power, and more, and so on."

The best peripheral velocity, or the best speed of rotation, has not been investigated by the author, or, at any rate, the investigation is not contained in the Paper. It could, of course, be calculated if the variations of prime and working cost with the speed were known. But, whatever its actual figure, it certainly will not be a high speed; it may be a very low speed. The result of this is that the best diameter for a fan of given power will be very large; large, that is to say, when compared with the sizes very commonly met with. The author does not appear to have taken the extra cost in fitting the fan, consequent on the large diameter, into account in his calculations. The larger size will necessitate more expensive work in adapting the fan to the place where it is to work. This will tend to keep the size down; but will probably not make any very considerable difference. Another effect of the increase in diameter will be to make it more convenient to apply the driving power to the rim of the fan, as is done in the Blackman electric fan, instead of to the spindle. A third, and very valuable effect, will be that there will be far less violent motion of the air immediately in front of the fan, and consequently less inconvenience to persons who may be there.

The Utilisation of Water Power on the Moselle.—In the Foreign Abstracts attached to the *Proceedings* of the Institution of Civil Engineers there is an interesting note with reference to the canalisation of the Moselle and of a short length of the Saar, which will form a connecting link between the canal systems of France and Germany, and will provide a most improved channel for the conveyance of iron and other materials. The annual traffic, over the length of 250 miles, has been closely estimated at 2,000,000 tons. Between Metz and Coblentz the total fall is 330ft., and this, in forty locks, gives an average fall of 8ft. 3in. per lock. The normal dimensions of the locks are: length, 362ft. 6in.; breadth, 32ft. 9in.; depth, 8ft. 3in. The water required for the series is therefore about 2,800,000 cubic feet, which at the normal level of the river is equivalent to twenty minutes' flow of the current. Each lock is constructed at the end of a weir; and, under the above conditions, a turbine at an effective power of 75 per cent. would develop 2,000 H.P., or a total for the length of the channel of 80,000 H.P. For a great part of the year this power would be increased by 50 per cent., and by adopting electric transmission of the power thus developed it would not be necessary for factories and works to be established on the river bank, but the power would be conveyed to any required point. The capital value of this power at its minimum and at its local rate would be £1,200,000, and the cost of the entire work is estimated at £2,000,000. It is proposed to deal in a similar manner with the Saar, the Lahn, the Lippe, the Ruhr, the Main, and other rivers.

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A 30-TON GEARLESS ELECTRIC LOCOMOTIVE.

We have received from the General Electric Company, of New York, particulars of a new electric locomotive which they have recently designed. We understand that this is the largest electric locomotive which has been manufactured by this Company; and it is claimed that it is the first electric locomotive of any considerable size in the United States. The gross weight of the locomotive is 30 tons, which is distributed among the four driving wheels, so that the adhesion of the full weight is utilised. The dimensions of the cage and frame, as shown in Fig. 1, are: length, 16ft. 6in.; width, 8ft. 4in.; and height,

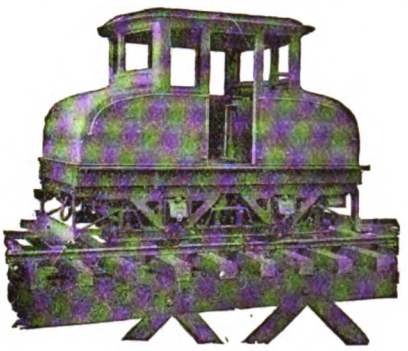

FIG. 1.

11ft. 6in. The driving wheels are 44in. in diameter, and the draw-bars are set to a height of 2ft 6in. from the top of the rail. Fig. 2 gives a perspective view of the motor truck. There are two motors, one on each axle, coupled direct to the axles; and the motors are supported on spiral springs resting on the side frames. By this method of suspension the wheels are free to adjust themselves to irregularities

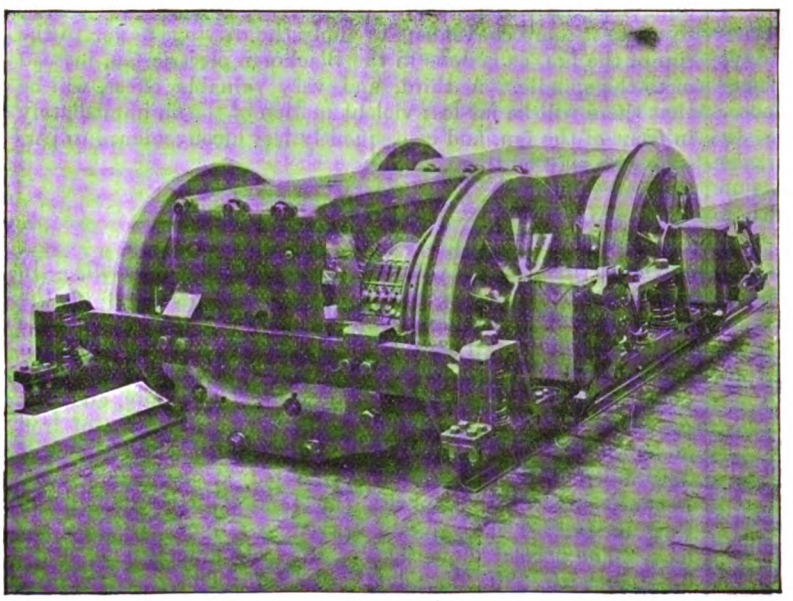

FIG. 2.

in the track. The motors are designed to exert a draw-bar pull of 12,000lb., and the normal speed of the locomotive is 30 miles an hour. It seems probable that the draw-bar pull of 12,000lb. is the estimated starting effort; in which case the normal pull at full speed would be between 900lb. and 1,200lb. At a speed of 30 miles an hour, this would represent a working power of from 70 to 90 H.P. The motor armatures are of the ironclad type, having each separate winding embedded in a mica-lined slot cut into the curved surface of the laminated iron armature core. At starting, the two motors are controlled by a so-called series-parallel controller, which is found to give a very satisfactory start.

The locomotive is provided with two air-brakes, supplied with air by means of an air-pump driven by a small motor. The air-pump also works the whistles. The air-pump has an oscillating cylinder, and a piston having a 6in. stroke; and it is capable of supplying about 3½ cubic ft. of air per minute, at a pressure of 70lb. per square inch. The pump motor is controlled by a special rheostat, which, by an intermediary device, is worked by the pressure of air in the air chamber.

NOTE ON A DETAIL IN PARALLEL WORKING OF ALTERNATORS.*

BY W. M. MORDEY.

In a recent Paper, "On Testing and Working Alternators," I ventured to incorporate a brief account of the principles on which I and my colleagues have acted for some years when dealing in practice with the parallel working of alternators.† In the course of the discussion on the Paper a criticism was made on a certain point, and was met only very briefly. As the matter is of interest, for reasons both of practice and of principle, it may prevent misunderstanding if I allude to it a little more fully, especially as Mr. Swinburne—my critic on the detail in question—has explained his views to me at length, and insists, on theoretical grounds, that my account of the supposed facts must be wrong. Theories may best be tested by applying them to definite and clearly ascertained actions.

The point is this: I stated in effect that two similar alternators similarly excited, driven by separate engines, could be run in parallel, and that, by sufficiently reducing the supply of steam to the engine driving either alternator, the current from that machine could be reduced to zero, or practically zero, without alteration of the excitation. I explained that in taking an alternator out of parallel the steam should be reduced till this condition was reached, and that the armature should then be switched off: and that in putting an alternator into parallel with another the engine should have only enough steam to drive the machine at the synchronous speed; that when switched in, the alternator will "merely keep in step, doing no work on the external circuit, and receiving no power from that circuit. This will be shown by its ammeter, which will show that no current, or only a very small current, passes between the machines." And that "the individual regulation of current (that is, of load) of each alternator is entirely by control of the steam supplied to each engine, and the regulation of the E.M.F. as a whole is by the control of the excitation simultaneously affecting all the alternators." This was criticised by Mr. Swinburne, who said that I was mistaken, that in order to get the current down to zero, or practically zero, the excitation must be lowered till the armature gave the station pressure, otherwise the no-load current must be large enough to reduce the armature pressure, by armature reaction, to equal the station pressure. Before switching alternators out of parallel I had been in the habit of reducing the current to "practically zero" (that is, to 3 or 4 amperes in a 50-ampere alternator, the ordinary ammeters not usually reading lower than this) without altering the excitation. Therefore I had some difficulty in believing it to be impossible.

The question, apart from all theories, is simply this: Is it possible or practicable, by reducing the steam, without reducing the excitation, to reach the condition that "the ammeter shows that no current, or only a very small current, passes between the machines"? This question was put to several engineers engaged in the actual running of alternators, and the following replies were received:—Mr. Shepherd, works manager to the Bournemouth Company, writes: "I find no difficulty whatever in reducing current practically to zero by means of governor and throttle valve. I do not alter field excitation of the machine before switching off, as it is unnecessary." Mr. Johnson, manager and engineer of the Sheffield Electric Light Company, writes: "We can and do reduce the current to practically zero, when switching off, by reducing the steam supply. We do not alter the field excitation of the machine before switching it off." Mr. Clirehugh, engineer to the central station established by the British Insulated Wire Company at Prescott, says: "We succeed in reducing the current practically to zero by means of the throttle valve without reducing the excita-

* From the *Journal* of the Institution of Electrical Engineers, Vol. XXII., No. 107.

† See *The Electrician*, Vol. XXX., March 10th, p. 546.

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tion. A slight flicker is, however, observable on the lamps, which is avoided if we reduce the excitation." Mr. G. C. Sillar and Mr. A. J. Lawson, two of my colleagues, state, with reference to five 2,000-volt 100-kilowatt alternators installed by them at Bangkok: "The alternators were excited in parallel from a common exciter. When about to switch off, we reduced steam at the stop-valve until the current from the machine was 4 or 5 amperes; probably we could have got the current lower, but we never tried. The excitation was not altered until after switching off. We ran various numbers of alternators in parallel, up to five, according to the load."

In dealing with this matter in a broad and general way it is not necessary to refer to such matters as the small difference of excitation necessitated by variations in resistance between cold and hot machines. I have referred to that elsewhere. It is easily provided for by a small resistance in each alternator field, but even that is a refinement, and not a necessity, and does not affect the question at issue, as we frequently work without it.

It must be understood that, as my experience has been principally with my own alternators, the foregoing remarks are not to be taken as applicable to machines of other design; they may or may not be.

PATENT LAW PROCEDURE IN THE UNITED STATES.*

The attention of Chambers of Commerce has of late been directed to a proposal that the English patent laws should be amended with a view of making them, so far as relates to preliminary examinations, analogous to the law and practice at present in force in the United States. A correspondent, well able to speak from the professional standpoint on British practice, and who also has a knowledge of American procedure, examined this proposition, with others, in "Notes on Certain Proposals for Patent Law Reform," which appeared in our March issue.† It was pointed out then that those who were urging the adaptation of English methods to the American standard were apparently not sufficiently informed of the grievances existing even in the United States. We have now received from the other side of the Atlantic a communication which strengthens the opinion that care is necessary in seeking for the introduction of the American system into this country; and, inasmuch as our correspondent speaks with that authority which can alone be acquired by practice under, and intimate acquaintance with, the system of which he treats the information he conveys—if it only succeed in inducing inquiry before specific recommendations for reform are made—will, we anticipate, be welcomed.

In the first place our authority states that under the system of administration of the United States Patent Office there are two applications. "One is called a caveat, which is intended to provide the inventor with the means of memoralising the evidence of his invention as soon as the crude idea is conceived, and before the practical operation thereof is sufficiently completed to be embodied in a specification. By this method the inventor secures his device without limitations in a general way. It is then filed in the secret archives of the Patent Office, and, for the space of a year, with a privilege of renewal the inventor is protected to the extent that, should a subsequent application of a subject-matter similar to that of his caveat came into the Office, the inventor will be informed of this fact, that he may with greater expedition complete his device and make his formal application. The utility of this method is manifest in that it gives the inventor the opportunity of officially fixing the date of conception and placing on record the best evidence of the date of invention. It leaves him at liberty also to expose his invention to the public during the process of completion, which is often necessary where the apparatus is of that character that it cannot be performed in secret, or where it is necessary to employ mechanics to carry out the idea. However, it is found in practice that this method is comparatively little used, though in some cases it has been found to be of the utmost importance."

Coming next to the practice of "preliminary examination," this is described as the "practice which makes the issue of the patent dependent on an examination of the state of the art at the time of the application; wherein lies the cardinal difference between the British and United States practice, the former being granted without examination."

The authority we are quoting says "the merits of these two plans have been the subject of much discussion. With the first establishment of our system the statute made it compulsory upon the Government to issue a patent without question, upon application; but it was found by experience that this practice was fraught with many dangers to the public, in that patents would be obtained from the Government which had no merit in fact, and were, indeed, a fraud upon the public. These would be made the subject of speculative values, and the commercial world would oftentimes be greatly deceived by reason of them.

"In view of this state of fact the law was modified by several statutes attempting to rectify the evil, culminating in the general Act of Congress of 1836, under which the Patent Office of the United States was established, and the Commissioner of Patents was given certain definite powers which constituted him a tribunal for numerous purposes relating to patents; that is to say, he was empowered to examine the state of the art, and to ascertain whether the application, as made, was patentable, and to reject or allow the patent as he might deem just, in view of the art. He had power also to determine the priority of invention between conflicting claimants; and out of these conferred rights have grown the great system of original examinations, and Boards or Courts of Appeal, wherein the questions involved may be considered. However, the powers of the Commissioner of Patents are limited to the extent that he is considered a judicial officer for the purpose of granting patents within the limitations of the Statute, and in proper cases his decisions can be reviewed by the Court.

"The patent granted to an inventor is, however, only *primâ facie* evidence of the fact that he is the first inventor, or entitled to the patent. All questions, excepting the formal procedure in the Patent Office, are subjects of review by the Courts of the United States, and in cases where the patent has been procured by fraud in the Patent Office formal questions regarding issue will be considered also.

"It will therefore be seen that there is ground for very serious criticism of the system, for the reason that the inventor is often put to great expense and delay in the procuring of his rights from the Patent Office to find, after his patent is granted; that he has got the same difficulties to contend with in the Courts to fully establish his rights."

The practical working of the system, granting that all difficulties are thrown in the way of the patentee, is somewhat as follows:—The applicant "first files a caveat, briefly describing his invention. He is thereafter notified that another applicant has filed either a caveat or an application for substantially the same subject-matter. He then completes his invention and makes his application in due form. He is then thrown into 'interference,' as it is called, with the rival applicant. For the purpose of determining who is the prior inventor, times are fixed for the taking of testimony, the hearing is had and award granted, from which an appeal may be taken. Then motions may be made for the dissolution of the interference on the ground that it was improperly declared, until, finally, priority is awarded to one of the inventors and his patent is issued. The defeated applicant then proceeds to manufacture and sell the subject-matter of the invention in defiance of the rights of the patentee, and the patentee brings his action for such violation. All the questions which were before the Patent Office, as regards the patentability and priorty of the invention, will be again considered *de novo* in these Courts, from which an appeal may be taken.

"Experience has shown that where large interests are involved, and expense is no object, immense delays can be had by reason of the abuse of this procedure, and where one of the parties has unlimited means and the other not the battle is a very uneven one, and substantial rights may be defeated by reason of the poverty of the inventor. Again, a number of cases have been brought to light in the last few years in which a conspiracy has been entered into between rival applicants, whereby their inventions have been tied up in the Patent Office for an indefinite time, going through the roll of appeals, amendments, and motions, until, finally, after the expiration of a suitable length of time, their patents are granted with the privilege of the full term of seventeen years from the date of granting, they having enjoyed, in point of fact, a practical protection during the period of their delays in the Patent Office."

From another source, also American, we are informed that the delays in the United States Patent Office are the subject of general complaint, and there is latent, if not expressed, approval, in influential quarters, of the English system. Confirming the statement we have already set forth above as to the indefinite time inventions lie dormant, our other authority cites instances of tying-up for seventeen years, another for eight years, and several for five or six years. In fact, so far from the American system being an ideal one, which, if adopted, is likely to remove such grievances as are complained of in connection with our method, that system has itself been the object of adverse criticisms and of proposed amendments. The original authority we have quoted declares that many reforms have been attempted, "but there has been so much opposition to the patent system by a certain class of the public that the reformers have feared to attempt radical changes, for the reason that they feared the whole fabric might be undermined."

* From the *Chamber of Commerce Journal*.

† See also *The Electrician*, April 7th, p. 651, and April 14th, p. 684, Vol. XXX.

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PARLIAMENTARY INTELLIGENCE.

The Dublin Southern District Tramways Bill.

The Committee of the House of Commons on the Dublin Southern District Tramways Bill have had under consideration the question of introducing into the Bill the model clauses recommended by the Joint Committee in substitution of a clause which had been agreed upon between the promoters and the National Telephone Company. The question first arose on Tuesday, July 18th, and the Committee adjourned the proceedings for the purpose of hearing the views of the National Telephone Company on the subject before finally deciding. Mr. Samuel Hoare was Chairman of the Committee. The promoters were represented by Mr. J. D. Fitzgerald; Mr. Pember, Q.C., appeared for the National Telephone Company, and Mr. Pembroke Stephens, Q.C., for the Dublin, Wicklow, and Wexford Railway Company, who were opposing the Bill. On resuming the proceedings on Tuesday last, Mr. Chandos Leigh, the Speaker's counsel, and Mr. Courtenay Boyle, representing the Board of Trade, were also present.

The CHAIRMAN, in opening the proceedings, said the Committee had again been considering the question, which was rather a difficult one, inasmuch as the Bill came before them under very exceptional circumstances. At the same time the Report of the Joint Committee had been laid upon the table of the House but not at present discussed. At the previous sitting, the Committee made some suggestions as to the possibility of settling matters of difference between the parties, but apparently there seemed to be some difficulty in carrying that out, and the question came again before the Committee now as to whether it was possible or not to introduce the model clauses. They feel, however, that they could not come to a decision until they had heard counsel, and they fully realised that there would be considerable difficulty in altering those clauses if they were to be introduced into the Bill, so that so far as they could at present judge, the clauses would have to be introduced very much in their present shape, though the Committee were quite ready to hear argument on the point. On Clause 5 the question of the number of years to be inserted would necessarily have to be a matter for consideration.

Mr. PEMBER said the Telephone Company had had to consider the matter very seriously from their own point of view, not only as an independent question affecting their own interest, but also from the point of view of having given an undertaking in the other House. His clients had set to work to see if they could do something in the direction of the model clauses with a view of bringing that Bill, by anticipation, into line with anything which might be done by the Board of Trade hereafter with the sanction of Parliament. Their difficulty was that it was premature to put into operation the model clauses, because they were not a final declaration of what Parliament intended to do, and that they must be read by the light of the recommendations of the Committee. They had suggested slight modifications in the clauses, and being met in a proper spirit by the promoters, they had agreed upon such modifications of the model clauses, which, in spite of what the Chairman had just said, he hoped the Committee would see their way to accept. The learned Counsel then read the correspondence which had taken place between the Parliamentary agents, the objections of the Company being stated in the following letter, dated July 24th, from the agents to the Telephone Company:—

"Our clients, the Telephone Company of Ireland, are anxious not unnecessarily to prolong the discussion before the Committee on the question of the protective clauses, and with this view they have been anxiously considering the suggestion made by the Chairman of the Committee on Tuesday last, whether it was possible for our clients to come to an understanding with the promoters on the subject. Our objections to the proposal to insert the clauses suggested by the Joint Committee in the pending Bills and Orders are twofold.

"1. The resolution of the two Houses appointing the Joint Committee directs that Committee to consider and report on the restrictions and provisions to be inserted in the grant of statutory powers to use electricity. The Committee have in effect, by sub-section 3 of the proposed clauses, relegated to the Board of Trade the duty of settling those restrictions and provisions by schedule to the Act or Order, or by subsequent regulations, and to insert the clauses suggested by the Joint Committee unaccompanied by such schedule, is in effect to insert a skeleton clause leaving the whole matter in the air. If words are inserted making it perfectly clear that any regulations which the Board of Trade may make, say within 12 months from the passing of the Act, shall be treated in all respects as if inserted in the schedule to the Act, and be as binding in all respects upon the undertakers, our clients would be satisfied on this point.

"2. The other point is this: Sub-section 5 contains a very serious limitation on the power of our clients to enforce the provisions of that sub-section by providing that at the expiration of —— years from the passing of the Act they shall have no right of action in respect of the provisions of the sub-section, unless they have taken steps to protect themselves, and the substitution of an insulated metallic return for the present earth return is specifically mentioned. This is a sufficiently serious matter to our clients, however it is looked at; but our clients are not seeking to take exception to the principle laid down. When, however, it is proposed to fill up the blank by reference to Resolution 10, it becomes essential for them to point out that this is to impose on them an impossible task.

"That this was not the intention of the Joint Committee is obvious, because in the prior resolutions they have recommended the use of an insulated return for telephone lines, deprecated the necessary duplication overhead, and recommended that to facilitate the use of these returns the necessary statutory powers should be granted to enable telephone undertakers to lay their lines underground. It is not too much to say that it is impossible in many crowded centres to duplicate the wires overhead, and yet if the clauses are inserted in your clients' Bill, with the blank filled up as proposed, the Telephone Company will have placed upon them the duty (indeed, the necessity) of duplicating their lines without any power whatever of doing it. They therefore submit that to incorporate the 10th resolution into the clauses, while ignoring the previous resolutions which alone make the later one practicable, would be in the highest degree unjust. Our clients, therefore, suggest that the two years should run not from the passing of the Act, but from the date at which the Board of Trade shall certify that the owners of the electric lines, wires, and apparatus referred to, possess reasonable facilities (whether by statutory power, consent from the Local Authority, or otherwise) for the execution of the necessary works. If your clients are prepared to meet the Telephone Company on these two points, they will not press their objection further."

They proposed to insert Clauses 1, 2, and 3, as recommended by the Joint Committee, unaltered, but at the end of Clause 3 they proposed to add "and such regulations shall have the same effect as if included in a schedule to this Act." Clause 3, as drawn by the Joint Committee, presupposed a schedule, but there was at the present moment no such schedule, and to embody Clause 3 *en bloc* without any modification would involve an utter absurdity. By that addition they gave in effect a schedule to the Act, but it would be necessary to make such an alteration for this occasion only, as next year the Board of Trade might have made their regulations, which could be put in as a schedule to the Act. Clauses 4 and 5 they did not touch until they came to the proviso which dealt with the blank number of years. If it had been necessary for him to attach the consistency of the recommendations of the Joint Committee and their clauses, he should have pointed out that it was not of the slightest use filling up the blank with any number of years after the passing of this Act, because it would have been inoperative if the promoters only waited for that period of years before they put their Act into execution. They had, therefore, agreed to modify the clause in this way: "Provided also that nothing in this sub-section shall operate to give any right of action in respect of or to protect any electric wires, lines, or apparatus or the currents therein, unless in the construction, erection, maintaining, and working of such electric wires, lines, or apparatus, all reasonable and proper precautions, including the use of an insulated return, shall have been taken to prevent injurious interference therewith or with the currents therein by other electric currents." That dealt with the matter as a compromise, and in the only way in which it could be dealt with any show of satisfaction to the parties on the present occasion. The whole thing being premature, so long as it was not licked into shape by Parliament or the Board of Trade, he hoped the Committee would not refuse to deal with this particular case in that special manner.

Mr. FITZGERALD (on behalf of the Promoters) intimated their acceptance of Mr. Pember's propositions.

The question arose as to the intervention of the railway company in the discussion, and

Mr. FITZGERALD said he thought they could not object as the railway company did not object to the model clauses, and all the alterations that were suggested were in favour of the telephone company or the railway company, as the case might be.

Mr. PEMBER said they must look to some of the recommendations of the Joint Committee apart from the clauses being carried out, and one of the most important of the recommendations was that facilities should be given to insulate their wires by putting them underground, while they also deprecated very much the multiplication of wires overhead. Until they got facilities for putting the wires underground it was perfectly clear if they duplicated at all it must be overhead, and that was against one of the strongest recommendations of the Committee. It was only under the special circumstances of the case that he asked the Committee to depart from the clause.

The CHAIRMAN asked if Mr. Pember would have any objection to the retention of the clause "provided also at the expiration of *three* years," that being the period they proposed to insert, if they afterwards inserted a further proviso giving the Board of Trade power to extend the time by an order which should be laid before Parliament.

Mr. PEMBER suggested that that was adding to the expense and machinery. His own amendment, he thought, was simpler, and Provisional Orders were expensive.

Mr. CHANDOS LEIGH said that what the Chairman suggested would not be any expense.

Sir COURTENAY BOYLE said that the order suggested was not a Provisional Order, but a documentary declaration.

Mr. PEMBER said that if it was understood that the Board of Trade had a perfectly free hand, in consequence of any circumstance brought to their notice, to extend the time, he should not object. So long as it was not a Provisional Order to be confirmed by Parliament, and which would give rise to a repetition of the wrangle over and over again, he was satisfied.

On the question of whether the period to be named in the clause should be two or three years,

Mr. PRITT (representing the City and South London Railway Company), in reply to the Chairman, said that the blank had been filled up in that case by the insertion of three years.

It was then agreed that the clause should be amended by the insertion of "three" years, and with a proviso that the Board of Trade should have power to extend the time by an order, and that in every such case the Board of Trade should make a special report to Parliament notifying the making of such order. The other modification suggested by the Telephone Company were agreed to.

Mr. PEMBER said that his clients were rather anxious that he should state that they did not wish their action on this particular occasion, which they considered special to themselves, to be quoted against them as a kind of precedent in other Bills, by saying, "You submitted to this in one case and are precluded from attacking the model clauses in other

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cases." They wished to preserve their full freedom of opposing the model clauses on their merits or demerits at any future time; but the present case was special, because of the fact that the clauses had not yet been finally adopted by Parliament, and on account of the undertaking into which they had entered in the other House.

The Committee then went through the clauses of the Bill, reserving till later their sanction of the precise wording of the protective clauses.

Before Lord Morley's Committee on Unopposed Bills the question of substituting the model clauses instead of the agreed clauses was raised on the Blackpool Tramways and London, Deptford, and Greenwich Tramways Bills, in respect to which powers to work by electricity are taken, and the Committee reserved their decision. In the case of the City and South London Railway Bill, providing for the extension to Islington, it was agreed that the clauses recommended by the Joint Committee should be inserted.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 14, 1893.

Incandescent Lamp Litigation.—The arguments in the incandescent lamp suit at Milwaukee (Wis.), was submitted to Judge Seaman on July 8th, and an opinion has been promised for July 17th. Very little new matter was brought up, although points previously used were greatly elaborated. A remarkable feature of the trial was the changing about of witnesses, several of whom directly repudiated their testimony given on previous trials. A sensational feature was the testimony of Goebel's son, who contradicted his sworn testimony on a previous trial, and swore that he had made the lamps upon which the Goebel claims were based, just previous to the Beacon case; scarcely less sensational was the production of an affidavit by a hitherto unknown son of Goebel's, who strongly sustained his father's claims. Many charges of bribery and perjury are being made, and it is probable that some of the witnesses will be prosecuted.

The Forthcoming Electrical Congress.—Foreign delegates to the Electrical Congress are beginning to arrive, but as yet only one full Commission seems to have been named—that of Great Britain. There is one member lacking from the French Commission. Dr. Helmholtz, for Germany, and Dr. Sahulka, for Austria, are the only others that are known to have been appointed to the Congress. Practical electrical engineers are agitating to have the Electrical Congress define the nominal candle-power of arc lamps in terms of watts, but it seems to be doubtful if any formal action can be taken. Frequent disputes have arisen between municipalities and electric lighting companies, and in the absence of any authoritative definition "experts" have generally made matters worse through their testimony.

CORRESPONDENCE.

THE VELOCITY OF GRAVITATION AND A RESISTING MEDIUM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It has probably often been noticed before, but if so there is no harm in noticing it again, that the consequences of a finite velocity of propagation of gravity, and the consequences of a universal medium which resists the motion of matter through it, tend to neutralise one another; so that it is just possible that both circumstances may really exist without having been noticed.

Gravitational aberration would result in an accelerating tangential force pulling the planet or satellite in the direction in which it is going, and its amount would vary directly with the velocity and mass of the planet. The effect of this force, if uncompensated, would be to gradually make the body move more slowly and get more distant from its centre of force.

A resisting medium, on the other hand, would pull back the planet by exerting on it a retarding tangential force, which if uncompensated would make it move more quickly and approach its primary.

It is probable that such a force, due to etherial viscosity, would be proportional to the first power of the relative velocity, and since the ether has been shown by optical facts to penetrate material bodies, and thus act on each atom of which they are composed, the force is not unlikely to vary also with the mass of the moving body.

Hence the compensation, if ever existent by reason of some unknown relation among the constants, would seem to hold fairly well for all bodies and at all speeds, except when the orbits are quite eccentric, but not excepting the case of an absolute drift of the ether past all bodies; though the effect of this last would need a little discussion to make it clear. Suffice it to say that if the ether possessed no viscosity, no aberrational disturbance to wave motion would be caused by such drift, whereas if the ether stream accelerated a planet viscously it would also curve the rays of force reaching it, in such a way as to make them pull it partly backwards.

The very interesting article by Mr. Heaviside in your issue of July 14th, on possible gravitational stresses and their propagation in time, suggests my sending this note to you.—Yours, &c., OLIVER J. LODGE.

INSTRUMENTS FOR MEASURING ALTERNATING MAGNETIC FIELDS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In view of your last week's note on M. D'Arsonval's instruments for measuring alternating magnetic fields, it may interest you to know that some 15 months ago I designed a similar instrument to obtain their shape. It consists essentially of an air thermometer with a flat bulb, in which is fixed a *thin copper disc*. Currents will be induced in this in all positions except that in which the plane of the disc is parallel with the (local) direction of the field. It may be used in two ways. In any one position it may be rotated to give a minimum and a maximum heating. In the first, the plane of the disc indicates the direction of the field; in the second, it is 90deg. removed.

Only one instrument was made, and that was too large, and so did not act well for my purpose. I hoped to apply it to examine some of the fields produced in the experiments of Dr. Fleming and Prof. Elihu Thomson. Pressure of other work has prevented further progress. The instrument is useful for demonstrating to elementary students the essence of magneto electric induction.—Yours, &c., W. HIBBERT.

14, Goldhurst-terrace East, N.W.,
July, 1893.

LEGAL INTELLIGENCE.

Re Slater Lewis.

This bankrupt, who is well-known in connection with the Birmingham Telegraph Factory, &c., and who was described as of Castle-hill, Ealing Dean, London, applied at the Birmingham County Court on Thursday last week for his discharge. He was described as a mechanical engineer. The Official Receiver (Mr. Sharpe) reported that the receiving order was made on the petition of Messrs. Archdale and Co., in April, 1892, and the bankrupt's statement of affairs showed liabilities of £1,613, which were all contracted since August, 1891, with the exception of about £100. Assets of £8 had been realised by the Official Receiver from the sale of a watch and chain, and £41. 13s. 4d. in respect of instalments of £4. 3s. 4d. a month, which bankrupt had voluntary paid out of his salary of £300 a year. Particulars of the early career of the bankrupt have previously appeared in *The Electrician*. In 1890 he formed, in conjunction with Messrs. Fowler, Lancaster, and Co., the Birmingham Telegraph Factory (Limited), and was appointed Managing Director. He remained with the Company till July of the next year, when he was approached by Mr. Richard Tangye with a view to forming a new electrical company. The negotiations fell through, and Mr. Tangye gave the bankrupt £750. Bankrupt then paid some debts, and with £525 left, started in business at Aston. In November, 1891, he floated a company under the name of the National Telegraph Works Company, the capital of which was to be £5,000. Bankrupt took 525 shares of £5 each, and six of his *employés*, with a share each, formed the necessary number of shareholders. No other shares were allotted, but debentures amounting to £800 were issued, and formed the capital of the Company. Most of the debts were incurred previously to the formation of the Company, and the stock, &c., bought before were transferred to the

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Company, which was to pay his creditors. In February, 1892, the Company was wound up, but the assets did not realise sufficient to pay any dividend to creditors. Mr. Sharp submitted that in November, 1891, the bankrupt must have been aware that the capital to float the Company had not been subscribed, and he ought not to have launched out as he did until he had satisfied himself that the money would be forthcoming. He had undoubtedly contributed to his bankruptcy by rash and hazardous speculation.

Mr. RICHARDSON (for the bankrupt) said the bankruptcy was due entirely to misfortune, and that the bankrupt all through the transactions acted in a perfectly *bonâ fide* manner.

Mr. BRADLEY (as representing Messrs. Archdale and Co.) said their complaint was that bankrupt got goods from them on credit, and without their consent transferred them to a company without assets. He might, having thus divested himself of everything, have walked off had not the petitioning creditors stepped in at their own cost.

His HONOUR asked what the bankrupt was now doing, and

The OFFICIAL RECEIVER read the following letter:—"W. T. Goolden and Co, Woodfield Works, London. Sir: *Re* J. Slater Lewis. Mr. J. Slater Lewis has been employed by my firm for the last fifteen months in the responsible position of works manager. I have seen a great deal of Mr. Lewis, and have formed a very high opinion of his character. He has proved himself to be a man of great energy and ability, and in all his relations with me of the most scrupulous honour. I consider him to be quite incapable of any questionable conduct.—I am, &c., WALTER T. GOOLDEN."

His HONOUR said no doubt the bankrupt fully and honestly believed that the company would be a success, but, nevertheless, he must say that when a man wanted to start a company and incurred debts on behalf of such future company, he was really risking his creditors' money instead of his own. Rightly or wrongly, under the existing law, a man could practically start a company of which he himself was the sole manager; in fact, the company itself. In this case the six other requisite persons took only a nominal share each, so that practically bankrupt was the company The law at the present time was in a curious and anomalous state. A man could incur debts, he could turn himself into a company with nobody else substantially a member of the company, and he could transfer all the property he had to a perfectly different set of creditors to those whom he previously owed money. This is what happened in the present case. He did not complain of the bankrupt for the curious state of the law, and he dared say bankrupt did not contemplate that curious state of things. The Company, although intended, no doubt, to be a *bonâ fide* one, did not go to allotment, and the prior creditors received no satisfaction. He hoped that the possibility of such a position arising again would soon be prevented. The law was in a very unsatisfactory state, and it was desirable that it should be taken into consideration, and a remedy discovered. He considered the bankrupt in this case intended to act honestly, but, under all the circumstances, his discharge would be suspended for three years. He was bound by the Act to suspend for at least two years any bankrupt who had not paid 10s. in the pound in a previous failure. If the bankrupt in the future found himself in a position to make a good offer, as there was rashness but no fraud in the case, he (the Judge) would be prepared to reconsider his order.

Mr. RICHARDSON replied that probably an application on those lines would subsequently be made.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1893 Edition of "THE ELECTRICIAN" Electrical Trades' Directory and Handbook is NOW READY. This useful book contains over 1,000 pages, and several new and handy features have been added. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

TENDERS INVITED.—The Vestry of St. Pancras invite tenders for extensions of their electric lighting works, including the building of an underground sub-station at Regent's Park, and the supply of storage batteries, armoured cables, bare copper strips, cast-iron pipes, laying mains, &c., and the providing of boilers, engines, dynamos, &c,, for the West St. Pancras Central Station. Conditions, specifications, and schedules of quantities can be obtained of Prof. H. Robinson, 13, Victoria-street, Westminster, S.W., and tenders must be sent in to Mr. T. Eccleston Gibb, the Vestry Clerk, the Vestry Hall, Pancras-road, London, S.W., not later than 12 o'clock, on Thursday, August 10th.

——— The Vestry of St. Pancras also invite tenders for various works in connection with the East St. Pancras Central Station, King's-road, N.W. Contract No. 1 is for the building of a chimney shaft, and Contract No. 2 for a subway under Georgiana-street, and for minor works. The conditions, specifications, &c., can be obtained of the Borough Engineer, Vestry Hall, St. Pancras, and tenders must be sent in to Mr. T. Eccleston Gibb, the Vestry Clerk, not later than 12 o'clock on Wednesday, August 16th.

TENDERS RECEIVED.—Tenders have been received by the Electric Lighting Committee of the Middlesborough Town Council for lighting the municipal buildings and Town Hall by electricity from the Brush Electrical Engineering Company, Limited (London), Messrs. Stevenson and Cowper (Middlesborough), and Messrs. J. H. Holmes and Co. (Newcastle). The tender of the latter firm was the lowest, the amount being £2,930, but after discussion it was decided to recommend the Council, in view of the present financial position of the town, and some prospective heavy outlays, not to entertain the question of electric lighting at present.

TENDERS ACCEPTED.—The Metropolitan Asylums Board have, subject to the assent of the Local Government Board, accepted the tender of the Electrical Power Storage Company (Limited), for the supply of apparatus for lighting by electricity the store rooms on board the "Atlas" and the "Endymion," the amount of the tender being £124. 16s. 11d.

——— The Watch Committee of the Worcester Corporation, at their meeting on Friday, decided to recommend the Council to adopt the Powick Mills site for a central station, and to accept the tender of a Birmingham firm for the erection of the building.

——— The Electric Lighting Committee of the Nottingham Corporation have accepted the tender of Mr. F. Messom, of Nottingham for the erection of the central station in Lower Talbot-street at the price of £10,209.

APPOINTMENTS VACANT.—The Electric Lighting Committee of the Borough of Kingston-upon-Thames are about to appoint a resident electrical engineer to take charge of their electric lighting works, and to have the management, the salary to commence at £150 per annum. Further particulars are given in our advertising columns, and applications must be sent in to Mr. Harold A. Winser, the Town Clerk, Clattern House, Kingston-upon-Thames, before noon on Thursday, August 3rd.

DISSOLUTION OF PARTNERSHIP.—The partnership between Henry Bowes Scott and Charles Robert Western, carrying on business at Broadway-chambers, Westminster, as civil and mechanical engineers, has been dissolved. The business will be carried on by Mr. Western under the old title.

ALLGEMEINE ELEKTRICITÄTS-GESELLSCHAFT, BERLIN.—We have received an illustrated pamphlet descriptive of this Company's exhibits at the World's Fair at Chicago.

MESSRS. RUSSELL AND CO.—This firm have just issued a new catalogue devoted to a description of engines and boilers supplied by the firm. The illustrations, descriptions, and prices, include nearly all the best-known types. The firm is prepared to supply all kinds of electrical and mechanical plant for lighting and power transmission purposes.

MESSRS. DOULTON AND CO.—This firm announce that their patent conduit for underground electric mains, together with a selection of pottery for electrical purposes, which has been exhibited at their Lambeth showrooms during this week, will remain on view to engineers, on presentation of card, until August 5th.

MESSRS. DRAKE AND GORHAM.—Amongst the recent contracts obtained by this firm is one for the electric lighting work required at the extensive offices of Messrs. Huth and Co., in Tokenhouse-yard, E.C.

MESSRS. VERITY AND SONS.—This firm's Manchester branch are busy installing the electric light all over the city, and have on hand installations at the Free Trade Hall, Royal Exchange, and Free Library, in addition to a number of private orders in the outskirts of the city, and in connection with the Corporation's supply.

MESSRS. JULIUS SAX AND CO. (LIMITED).—This Company have applied to the Court of Common Council for a lease for 80 years of land in Charterhouse-street, on which they would erect a station for the generation of the electric light for the markets. They undertake to surrender the land again to the Corporation if it were required for market purposes, in which event they suggested the Corporation should pay them £7,000 compensation. Some considerable discussion ensued, and finally the petition was referred to the Markets Committee for consideration and report.

MESSRS. CHARLESWORTH, HALL AND CO.—We are informed by this firm that Messrs. Appleton, Burbey, and Williamson no longer represent them as London agents.

PRACTICAL NOTES FOR APPROXIMATE CALCULATIONS.—We have received from Mr. H. A. Mavor, of Glasgow, a copy of a set of rules and formulæ, which he has drawn up, for the purpose of assisting electric light engineers in rough calculations. The rules cover a wide ground, and appear to be based on average practice; they include water power, steam boilers, simple engines, belting, dynamos, storage batteries, conductors, and light. The sheet on which these rules are printed could conveniently be pasted inside a small pocket-book.

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GAS, WATER, AND ELECTRIC LIGHTING STATISTICS, &c.—Messrs. Watson, Hazell, and Viney forward us a copy of their "Gas, Water, and Electric Lighting Directory for 1893," just issued. The book has additional sections dealing with gas and water companies' statistics, and much of the information given will be found of use to our readers. The price of the book, bound in cloth, is 10s. So far as we have been able to test the information given concerning electric lighting undertakings, it would appear that the opportunity has been missed (seeing that the book is apparently not published until July) of making many corrections calculated to improve the accuracy of the book.

BECKENHAM.—At the last meeting of the Local Board a committee was appointed to undertake the consideration of all matters relating to electric lighting.

BRADFORD.—At their meeting on Monday the Gas and Electricity Committee of the Corporation commenced the consideration of Lord Kelvin's report, a decision in the matter being postponed until the next meeting.

CHESTER.—At the meeting of the Corporation last week the Town Clerk stated that a report had been submitted to the Watch Committee by Mr. W. H. Preece suggesting a site for the electric light station, and recommending the adoption of the low-pressure system, to which could afterwards be added the high-pressure system with alternating currents and sub-stations if a sufficient demand arose. He estimated that the initial outlay would be £15,000. At a previous meeting the Watch Committee had appointed Dr. Hopkinson as Chief Engineer, and had instructed him to prepare a scheme, but nothing had been finally done in the matter. Mr. W. H. Churton remarked that the Committee had been empowered by the Council to proceed so far with the matter, but they had committed themselves to nothing, as they could not accept a tender without the sanction of the Council.

COWPEN.—Mr. Sanderson, the electric light contractor, has been mulcted in penalties for non-supply of the light on one occasion; but as he ascribes the failure to the fact that he could get no water for the boilers, a conference is to take place between him and the Finance Committee.

CRYSTAL PALACE.—Arrangements are being made for the introduction of the electric light throughout the entire building, which will be fully installed at the termination of the present contract.

THE ELECTRIC LIGHTING OF THE MANSION HOUSE.—The Court of Common Council last week passed the account of the City of London Electric Lighting Company for current supplied to the Mansion House for the half-year to Midsummer last, the amount being £449. 18s. 11d.

GOOLE.—An Art Exhibition has recently been held at Goole, which was lighted by electricity. We understand that the light has given great satisfaction, and inquiries are now being made as to the probable cost of its intoduction into the town generally.

HADDINGTON.—At the last meeting of the Town Council the Clerk stated that, regarding the water power at the East Mill, a London firm of engineers had reported that the normal horse-power of the water was not sufficient for the purpose of supplying the power for lighting the burgh, but that it might be supplemented by steam, as had been done in other places. A discussion followed, but a motion to appoint a Committee to consider the question was negatived.

HERTFORD.—The Corporation recently submitted Mr. J. A. McMullen's scheme for lighting the town to Prof. Forbes for confirmation, and he has, we learn, agreed with Mr. McMullen's proposals on all important points, so that in all probability the alternating system of distribution with transformer sub-stations, and gas engines, driven by Dowson's gas, will be selected.

KILLARNEY.—At the meeting of the District Lunatic Asylum, last week, Mr. Walter Leake submitted his report upon the proposal to light the Asylum by electricity. It will be remembered that the Asylum Board a few weeks ago accepted a tender from the Killarney Electric Light Company (Limited) to supply the light at a cost of £185 per annum. Mr. Leake recommended that this tender be modified so that the current should be taken at 4¾d. per unit, and that a guarantee be given by the Board that the amount of current consumed should not be under the value of £150 per annum. He had carefully examined the Asylum, and came to the conclusion that 295 8-c.p., 251 16-c.p., 9 32-c.p., and 6 100-c.p. lamps would be required. To carry out the installation properly a sum of £1,200 should be expended in fittings, &c. It was resolved that a copy of the report be sent to the Company, and that they be asked to tender for the supply and erection of the fittings, &c. A notice of motion was, however, given for the next meeting that the whole matter of the electric lighting should be reopened and further considered.

LEICESTER.—The Ratepayers' Association have decided to appear before the Commissioner who is shortly to hold an inquiry on behalf of the Local Government Board respecting the subject of the electric lighting of the town, and to oppose the proposed scheme.

MANCHESTER.—The Special Sub-Committee of the Corporation, appointed with reference to the subject of telephones and electric traction, reported at the last meeting of the City Council that in pursuance of their instructions they united with other municipal Corporations of England and Scotland in appearing by counsel and giving evidence before the Joint Committee of both Houses of Parliament dealing with the matter. The clause which the Joint Committee adopted, and which was to be inserted in all bills or Provisional Orders which authorised the undertakers, other than electric-lighting undertakers, to use large electric currents, was more favourable to electric traction than the form of clause contended for by those interested in telephone wires. The results of the action by the Municipalities had been, generally speaking, satisfactory. They thought that the recommendation of the Joint Committee as to placing the telephone wires underground would render it necessary for the Municipal Corporations to consider what action should be taken by them upon any Bill in Parliament which might be introduced for dealing with the subject. On the motion of the Lord Mayor, the report was adopted.——In reference to a report which appeared in a contemporary last week that the fire which occurred at the Manchester Free Library was caused by the electric lighting work, we are requested to state the report is false; the electric light has not been installed nor will it be for some weeks. It is more than likely that the fire arose through the upsetting of a lamp used by the workmen engaged in the dome of the building; and we learn that Messrs. Verity and Sons, who have the electric lighting in hand, have been exonerated from all blame in the matter. The daily press was, no doubt, the source of our contemporary's information, but where it is possible to obtain confirmation or denial of such statements it is most essential in the interests of the industry that every effort should be made to do so. Doubtless the false report will be made the most of by the opponents of the electric light.

OSWESTRY.—The Town Council have decided not to oppose the proposed application of the Oswestry Electric Light and Power Company to the Board of Trade for a Provisional Order.

PLYMOUTH.—Major-General Hutchinson, R.E., C.B., held an inquiry at Plymouth last week concerning an application of the Corporation to the Board of Trade for sanction to borrow a further sum of £13,000 for the purpose of fully equipping the tramways which they recently purchased from the Plymouth Tramways Company. The Town Clerk, in supporting the application, said that as regarded the question of utilising electric motive power the Council had decided not to adopt the overhead system, and the gradients were so steep on the main line that that portion could not be worked on the accumulator system. It was possible, however, that the lines in the lower part of the town, which had been sanctioned by the Board of Trade, and which they hoped would shortly be sanctioned by Parliament, might be worked advantageously by electricity.

REDDITCH.—The Local Board have instructed Mr. J. A. McMullen to advise them on electric lighting matters generally, and to prepare a complete scheme for the town installation.

SEVENOAKS.—The Local Board at their last meeting decided not to oppose the proposed application to the Local Government Board by Mr. Hemmant for a Provisional Order for lighting the town.

SHREWSBURY.—In March, 1891, the Town Council transferred to the Shropshire Electric Light and Power Company (Limited) their powers under a Provisional Order, with the understanding that the Corporation might purchase the rights and property of the Company at the end of 7, 14, or 21 years. The Company have recently requested the Town Council to extend this time, so that 21 years should be the minimum period for purchase, and at a meeting of the Council last week it was decided to extend the period to 21, 28, or 35 years.

WEYBRIDGE.—The Chertsey Rural Sanitary Authority last week resolved to draw the attention of the Weybridge Electric Supply Company (Limited) to the section of their Order which limits the time for removing the overhead wires, and to inform them that the Authority could not consent to the wires remaining above ground in contravention of that Order. It was stated that the contract originally entered into had only about 14 months to run, and if the Company failed to comply with the terms of the Order it would be necessary to make some arrangements for the lighting of the parish.

WOLVERHAMPTON.—Mr. S. J. Smith, C.E., held an inquiry on Tuesday at the Town Hall on behalf of the Local Government Board with regard to an application by the Town Council to borrow, amongst other sums, £1,927 for electric lighting purposes. There was no opposition, and the proceedings were merely formal.

WREXHAM.—The Town Council on Tuesday resolved to open negotiations with the Wrexham and District Electric Supply Company (Limited), as to the taking over of that Company's Provisional Order. They will not, however, adopt or take over any contract for work in connection with the supply of electricity that may have been entered into by the Company.

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PATENT RECORD

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fcl. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

July 5, 1893.

13,218. THE LITHANODE AND GENERAL ELECTRIC COMPANY (LIMITED) and J. T. NIBLETT. London. Improvements in plates or elements for secondary electric batteries.

July 7, 1893.

13,263. C. A. ALLISON. London. Electric apparatus for operating dental implements. (Oscar Henry Pieper and John Henry Harbour, United States.)

13,274. C. ROUSSEAU. London. Improvements in the manufacture of plates for electric accumulators.

13,276. E. JOKL and C. HOLZAPFEL. London. Improvements in and relating to electric arc lamps.

13,279. R. SEIFFERT. London. Improvements in ear pieces for telephones.*

July 8, 1893.

13,336. C. HOEPFNER. London. Improvements in the electrolytical production of nickel and other metals.

13,339. H. H. LAKE. London. An improved manufacture of carbon for electrical purposes. (Adam Charles Girard and Ernest Auguste, Georges-street, France.)

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

12,665. GARASSINO. Secondary batteries.

13,207. STIRN. Incandescent electric lamps.

13,358. MORDEY. Alternate current circuits.

13,507. SCOTT. Electric conduits.

14,819. WATT. Electric arc lamps.

15,319. FEDERMAN. Electric batteries.

15,887. FREI. Obtaining metals by electrolysis.

17,438. ROYCE. Electro motor and rotary fan.

17,702. JOHNSON (Lattig and another). Electric signalling for railways.

17,982. BOULT (Boudreaux). Brushes for electric current machines.

18,502. WISE (Diatto). Electrical railways and tramways.

23,657. FRIED. Incandescent lamps.

1893.

7,437. LEIGH (Mildé, Son and Co.) Microphone.

10,283. HOFMANN. Electrode plates for secondary batteries.

10,501. PRICHARD. Heating liquids by electricity.

COMPANIES' MEETINGS AND REPORTS.

Globe Telegraph and Trust Company (Limited).

The twentieth ordinary general meeting of the Globe Telegraph and Trust Company (Limited) was held yesterday at Winchester House, Old Broad-street. Sir John Pender, G.C.M.G., M.P., presided.

The SECRETARY (Mr. Sidney Collett) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: I shall, as usual, make a few remarks supplementary of the report, so that you may have a thorough knowledge of what has been doing since I last had the pleasure of addressing you. The receipts for the year ended July 18th inst., after payment of expenses, amounted to £188,931, as against £192,243 last year, or a decrease of £3,312. This decrease, which I may say is but a small one considering the general depression which has existed during the past year, is accounted for by the fact that we have received somewhat reduced dividends from four or five of the companies in which we hold investments. On the other hand, there are two or three companies who have given us a better return this year than we received in the corresponding period of 1892. This, gentlemen, enables us to recommend to-day the payment of a dividend on the Ordinary shares of 4⅝ per cent. for the year under review. Last year, you will remember, we were able to pay 4⅞ per cent., or 6d. more than we propose to pay this year. When, however, we consider that the average dividend which this Company has paid since its formation in 1873 has been 4⅜ per cent., you will observe that our present dividend is above that average, and is, therefore, not discouraging; and if we take our Preference and Ordinary shares in like quantities they show a return of £5. 6s. 3d. per cent. I will now, gentlemen, refer more particularly to the dividends we have received from those companies which show increases or decreases as compared with last year. It will be seen, on reference to the report, that at the beginning of this financial year the amount brought forward was £936 less than the amount brought forward at the beginning of last year. The Brazilian Submarine Company has paid us £1,092 less than we received last year, this reduction being due to the fact that they have had to lower their rates in consequence of the competition which has existed from the South American Cable Company. Notwithstanding this reduction the return on those shares is 6½ per cent. for the year. The Telegraph Construction and Maintenance Company, I regret to say, gentlemen, has paid £2,188 less than they paid us last year. This is accounted for by two circumstances:—Firstly, the general depression which has existed in all departments of trade; and, secondly, the fact that during the year under review there have been no large orders executed by that Company. I may say, however, that the Chairman in his speech at the general meeting in February last stated that he hoped the reduction in the dividend paid would only be a temporary one. Still, the return on these shares, though less than last year, is £4. 19s. 9d. per cent. You are aware that the Telegraph Construction and Maintenance Company's dividend was a very large dividend; they paid 20 per cent., which is rather an unusual dividend in these times. They reduced it, however, to 15 per cent., but I believe they are now very full of business, although I am not very sanguine that they will revert to their 20 per cent. dividend for some considerable time. I think they will probably strengthen themselves in other ways, but, still, 15 per cent. is a dividend which I think most of you will consider a very fair and satisfactory one. The West African Telegraph Company, gentlemen, I regret to say, has not been able to make any return in the way of dividend during the past year. During the previous year they paid us £1,258, but this loss is looked upon as purely a temporary one, owing to the exceptionally heavy expenses which that Company has had to incur on account of the frequent interruptions to its cable off the mouth of the Congo. I may say here, for your information, that the West African Company has now taken steps to remove that cable from its former position, whereby it is fully anticipated that the cable will not be so liable to these interruptions which have proved so costly in the past. I may mention that this cable lay across the mouth of the Congo, and we have found from experience that these large rivers flowing into the sea have under-currents, of which we have all of late years been able to realise the power—the power which they have upon cables. We have therefore taken up that cable and relaid it 150 miles from the mouth of the Congo. The work is done, the cable is working satisfactorily, and I sincerely hope that we have got rid of the trouble and difficulty we have had at the mouth of the Congo. I may mention that during the year we have made three repairs in that cable, involving an outlay of £13,000, and if that amount had been in the exchequer instead, the West African Company would have paid a fair dividend. I hope that the next time I have the pleasure of meeting you I shall not have the misfortune of being obliged to say that we have received no dividend from that Company. We have also received a somewhat smaller dividend from the Western and Brazilian Company, namely £1,494, as against £2,391 last year, or a reduction of £897. This reduction, as in the case of the Brazilian Submarine Company, is partly due to the competition which has existed, to the depression in commercial affairs in South America, and the loss on Exchange. On the other hand, gentlemen, we have received a larger dividend from the Anglo-American Company, which shows an increase of £1,092 over the amount received from them last year. The dividends from this Company show a return of £2. 18s. 3d. per cent., as against £2. 16s. 1d. per cent. last year. We have received £1,025 more from the Submarine Cables Trust than they paid us last year. The investment under this heading shows a return of £6. 10s. 7d. per cent., as against £5. 1s. 6d. per cent. last year. We have also received a somewhat better return this year from the Western Union Telegraph Company, as compared with last year. We have received from this Company a certain amount of bonus shares during the year, and these have added to the value of our property. The returns on the other investments are practically the same as last year. It will be seen on reference to the report that we still receive large returns from some of the companies in which we have investments, notably, the Indo-European Company, the Eastern Extension Company, the Eastern Telegraph Company, and the Direct United States Company. I may say that during these very unsatisfactory times, probably the most unsatisfactory which have been experienced in London for a very long number of years, our submarine telegraph system, over which we have more or less control, has held itself probably in a higher and more satisfactory position for the shareholders than any other class of investment that has come under my notice. I hope that that state of things will continue. There is no doubt at all that during the depressed times telegrams come freely and frequently over our system. In lively times times business is good, and we have a similar experience then. At the same time where there is a general depression existing it affects us more or less in this way—that it interferes with what we call our legitimate trade traffic. The extra traffic that seems to come in dull times comes from sources which are less satisfactory than when they come from legitimate commercial transactions. The last time we met here Sir James Anderson was re-elected a Director. As you are aware, Sir James Anderson had been connected with telegraph enterprise for the last 25 years. He was always a zealous, hard-working man, and a man whose nautical experience—he had been a sea captain for many years of his life—made his services most valuable to the Company. He was a most satisfactory colleague to work with. He was always willing and ready to do his share of the work, and he was at the same time always sufficiently informed to impress his confidence upon his co-Directors. By his death we have lost a valued colleague and a very loyal man in his adhesion to the telegraph enterprise. His place, as you are aware, has been taken by the Hon. William St. John F. Brodrick, a Director of the Brazilian Submarine Company. As you are aware, this Company exists very much by its investments in submarine telegraph companies, and we try as far as possible to have a fair representation on our Board of the different companies. I have just mentioned about the hard times that we are passing through, and they are very hard

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times indeed, but I remember the old-fashioned belief in regard to cycles of times. Cycles of bad times, it used to be said, are followed by cycles of good times. I hope that we have pretty well passed through the cycle of bad times, and that there is now a silver lining coming into view; and before we meet again I trust that we shall see a more healthy state of things than exists now. Still, I must caution you that there are circumstances and causes existing at the present time that have not come to the surface for a very long time past, and one in particular is the silver question. I am not going to discuss the silver question to-day, but I may mention that that question affects a great many of the companies in which we have investments, and to an extent which sometimes astonishes even people who are accustomed to deal in large figures. The loss in remitting money from these places to England is sometimes very serious indeed. We who are managing these companies endeavour to obviate the evil and reduce the loss as much as possible by increasing the rate, so as to make up for the loss, but even that does not always meet the expectations that we form, and it does not always recoup the loss which is sustained. However, I hope that that is passing away, and that with better times we shall also have an improvement in the position of they telegraph companies generally, and as they improve so shall we. It is interesting to mention, at a time like this, the general progress of telegraphy. As you are aware, telegraphs have nearly grasped the whole of the civilised world. There is scarcely a place where the British flag flies or where British influence and trade are exercised that telegraphs do not reach. A contract is just about to be completed by the Eastern Company with the Government for a cable to the Seychelles and Mauritius. That has been long talked about, and is very much wanted, and I believe now that within the next few months it will be completed. The Eastern Company have also made an arrangement with the Portuguese Government for carrying a cable to the Azores. This is a scheme which the French took an active interest in, and a year ago they actually had possession of the contract. But circumstances change rapidly in France, as you are all aware, and the result came about that the Government who had promised to support the French Company did not do so. The Government changed, and the result was that the French Company lost the contract, and we stepped in and secured it. We believed that we originally had the contract, but the French obtained it through offering terms which we did not consider prudent. However, we have now got it, and I hope that before the end of September the work will be completed by the Eastern Company. I think that is all the information that I have to give you. In regard to the position of submarine cables I may, however, say just one word more. The commerce of the world at the present time is being very largely conducted by telegraphy, supplemented, it is true, by the mails, but the origin and termination of business transactions are now almost invariably carried on by the telegraph. I hope that the commerce of the world will grow, and if so we may expect also to grow with it. The resolution which I have now to propose, gentlemen, is as follows:—

"*That the printed report and accounts for the year ended July* 18, 1893, *submitted to this meeting be, and the same are, hereby received and adopted, and that a dividend be now declared, payable on and after this day, of* 3*s. per share on the Preference shares, less income-tax, and of* 4*s. per share on the Ordinary shares (income-tax having already been deducted), making, with previous payments, a total dividend for the year of* 6 *per cent. on the Preference shares, less income-tax, and of* 4⅜ *per cent. net on the Ordinary shares of the Company.*"

The Marquis of TWEEDDALE seconded the motion.

Mr. WILLIAM GRIFFITH said that the Chairman's statement was so clear and satisfactory that there was nothing for the shareholders to inquire about. He desired, however, to testify—as he thought he might be allowed to do on the part of the shareholders generally—to the integrity, the skill, and the knowledge of telegraphy which the late Sir James Anderson displayed. It was gratifying to find that the place of the deceased gentleman had been filled so satisfactorily. They were all deeply interested in telegraphy, which was of essential importance to the commerce of the world, and he really thought that it did more good in the world generally than the Peace Society or the principle of arbitration.

The CHAIRMAN stated that the Directors, on their own behalf and on behalf of the shareholders, had already expressed their sympathy with the family of the late Sir James Anderson, but they would again convey to them the views which had been expressed by Mr. Griffith—feelings which he understood were unanimously shared in by all present.

The resolution was then carried unanimously.

On the motion of the CHAIRMAN, seconded by Lord SACKVILLE A. CECIL, Sir H. D. Gooch, Bart., was re-elected to his seat at the Board; as was also Mr. James Pender, on the motion of the CHAIRMAN, seconded by the Marquis of TWEEDDALE.

Mr. S. JOLLY then proposed, and Mr. FOSTER seconded, the re-election of the auditors, Mr. John G. Griffiths, F.C.A. (Messrs. Deloitte, Dever, Griffiths, and Co.), and Mr. William Griffith, and the motion was carried unanimously.

Mr. CARPENTER suggested that a column should be placed in the accounts showing the value of the different stocks held by the Company.

Sir H. D. GOOCH: They vary from day to day.

Mr. JOHN GRIFFITHS pointed out that it would be inexpedient and undesirable to act upon the suggestion of Mr. Carpenter.

The CHAIRMAN said that the Directors were very anxious to consider any suggestion which would give satisfaction to the shareholders, but the latter must not throw undue responsibility upon the Board. If they had had large investments—which, fortunately, they had not—in American securities, they would have seen a very great difference indeed in the prices that day compared with the prices 14 days ago.

Mr. CARPENTER said that of course the valuation should be taken on the day of the report, but the explanation of the auditor was quite sufficient, and if it was impolitic to give the information he desired that his suggestion might be considered withdrawn.

A cordial vote of thanks was then passed to the Chairman and the Directors for the satisfactory and efficient way in which the affairs of the Company had been administered.

The CHAIRMAN, in acknowledging "this oft repeated evidence of the shareholders' goodwill and confidence," remarked that it was a very great source of satisfaction to the Directors to be able—especially in times of financial disaster like the present—to show that their own affairs had been piloted so well through the sea of trouble. The position of the submarine telegraph enterprise stood high in the confidence of the shareholders, but he thought that those who were trusting to telegraphy in the present hard times were not in any way disappointed. Fortunes were, more or less, lost or won by prompt attention, and it was, therefore, a great fact to know that by means of submarine telegraphy London could communicate within a couple of hours with almost any part of the world. This was a great fact, and they could very well understand what an enormous boon it was, commercially, politically, and socially.

The proceedings then terminated.

Telegraph Construction and Maintenance Company (Limited).

In accordance with the resolution of the general meeting of February 28, 1871, a half-yearly general meeting of the Telegraph Construction and Maintenance Company (Limited), was held at 38, Old Broad-street, on Tuesday. Mr. Philip Rawson presided.

Mr. W. SHUTER (Managing Director) having read the notice calling the meeting, as above,

The CHAIRMAN said: You are probably all aware that at this meeting we have no figures to lay before you, or any resolution to propose, and therefore, as briefly as possible, I will lay before you a few points of interest with regard to what is going on in our Company. During the half-year that has just passed we have undertaken a contract for the laying of about 190 miles of cable on the West Coast of Africa joining up the Cameroons to Lagos. We have also entered into a contract with the Eastern and South African Company for the laying of a cable on the Eastern Coast of Africa from Zanzibar to the Seychelles and thence to Mauritius, a distance of about 2,300 miles. That, we hope, will be completed in the course of the present year. We have also obtained a concession for the laying of a cable from Lisbon to the Azores from the Portuguese Government, and that undertaking, I believe and hope, will be completed in the course of a month or two from this date. These are the principal contracts we have entered into and the chief amount of work in hand. The whole affair involves a manufacture of about 3,500 to 4,000 miles, about 2,300 of which are already completed. The general business of the Company has remained in a satisfactory condition during the past half-year, and the business at the gutta-percha works is somewhat in excess of what it has been in any previous year. I think when I have said that I have said all that is of any interest to you, but I shall be happy to answer any question you may wish to ask. I have no resolution to propose.

Mr. SYKES inquired whether the shareholders were justified in hoping from the statement just made by the Chairman that the final dividend for this year would be an improvement on the last.

The CHAIRMAN: That is a very difficult question to answer; indeed, it is almost impossible to answer it. Hitherto all the contracts we have undertaken we have carried out without any mishap; but it is impossible to say that an accident will not occur in the laying of any one of these cables, and in the event of an accident it might be very prejudicial. I hope and trust that no such accident will take place, but it is impossible to forecast the profit we may derive beforehand from any one of these undertakings. On the whole, the business of the Company is going on favourably, but I should not like to commit myself to any figures. I feel it would be an improper thing to do at the present time.

Mr. SYKES said he had asked the question because the final dividend of last year was so exceedingly disappointing, and he thought it was the general opinion of the shareholders that the explanation given to account for it was very meagre. Of course, he was aware that in case of an accident happening it would be impossible to answer the question which he had put. What he had meant to ask was whether, barring accidents, they might hope for an improved dividend over that of last year.

The CHAIRMAN: I must say that I should not like to commit myself to any prophecy. The business of the Company is going on prosperously and well, I hope, and I trust that there may be no disappointment; but I commit myself to no statement. Unfortunately, I was not present on the last occasion, being very ill at home, and I do not know what took place. Therefore, when you say that the explanations given on that occasion were inadequate, I am sorry that I am unable to add to them.

Mr. BOYD asked how the work in hand now compared with that which they had last year.

The CHAIRMAN: As far as I remember, we are doing more work this year than we were last year.

Mr. BAYFORD said that theirs was an old-established Company, and he thought it would be desirable if the Board could give the shareholders a little more explanation. There had been, owing to circumstances which, he had no doubt, were perfectly natural and explicable, a fall in the value of the shares and in the amount of the dividend. If the Directors could give the shareholders some information on this point he certainly thought it would be well.

Mr. SYKES said that the dividend last year was a third of what it was in the previous year.

A SHAREHOLDER: No, no.

A SHAREHOLDER: You mean one-third less than in the year before.

The CHAIRMAN: No, it was one-fourth less; it was 15 per cent. We have been paying for many years past 20 per cent., and have had an extra-

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ordinary run of prosperity. One year comes, and we are not able to keep up the old dividend, but that is a very natural thing to have happened, and the wonder is that it did not occur before. I should think you would find very few companies with such a record as ours. I cannot add anything to what I have said. We must hope and trust in the future, and I hope that you will not be disappointed when we declare the final dividend.

Mr. BAYFORD observed that the dividend was a very good one; but there was a falling-off in it, and that arose from increased competition or increased cost of work. Surely they might have an explanation on such a point as that. If the Chairman could say that it was not desirable in the interests of the Company that these questions should be answered he would not press them any more; but he thought there might be some little indication given as to how it was that, although they were in a very prosperous condition, they were not in such a prosperous condition as before.

The CHAIRMAN: I have told you that we are more prosperous now than we were last year. We are doing an increased business, but what the final result will be I cannot tell.

A SHAREHOLDER: You are doing more work?

The CHAIRMAN: We are doing a great deal more work than we were a year ago.

A SHAREHOLDER: At as good a price?

The CHAIRMAN: Yes, I should say at as good a price.

The Rev. E. HAWKIN asked whether the decline in the dividend last year was owing to a diminution of work or to an increase in the cost.

The CHAIRMAN: As I have said, I was not present at the last meeting, but I believe the matter was explained. It was owing to a diminution of work, and at the same time lower prices. In other words, there was less work to do and more competition, with the natural result.

A SHAREHOLDER asked whether the interim dividend was going to be paid, as usual.

The CHAIRMAN: Yes, it will be posted to-night. I ought to have mentioned that, and I am glad you have done so.

The proceedings then terminated.

Chili Telephone Company (Limited).

The following is the report of the Directors of this Company for the year ended March 31st last. The shareholders' meeting takes place at Winchester House, E.C., on Wednesday, August 2nd, at 12:30 o'clock.

The business of the Company during the past year has shown a satisfactory improvement in dollars, but has been less profitable in sterling than that of previous years. This result is due to the depreciation in the sterling value of the dollar, which has fallen from 19d. on March, 31, 1892, to 15d. on the same date this year. The income in dollars from subscribers and other sources for the year ended 1892-3 was $448,661, and for the previous year, $378,830, showing an increase of $69,831. The maintenance, operating, and general expenses in Chili were, in 1891-2, $271,180, and in 1892-3, $263,988, or a reduction of $7,192. The increase of income having been $69,831, and the diminution of expenses $7,192, the total result was more favourable than in 1891-2 by $77,023. The outgoings in 1891-2 were 71·6 per cent. upon the gross revenue, but in 1892-3 they fell to 58·8 per cent., a reduction of nearly 13 per cent. This satisfactory increase of profit was in dollars only; the unfavourable rates of exchange reduced the available income in sterling very considerably: The net profit on working was in 1892-3, at 18d. the dollar, £13,850; and in 1891-2, at 19½d. the dollar, £3,746; showing an increase, notwithstanding the fall of 1½d. in the average value of the dollar, of £5,104; but the loss on the sterling value of the liquid assets on March 31st, comparing the same two years, was 4d. per dollar, and amounted to £4,750, and that therefore the net increase in sterling was only £354. The increase in the outgoings in England—including the interest on debentures—was £1,027, so that the net available sum for the year is less by £673 than in the previous year.

The profits having been used for capital purposes cannot be divided, and consequently the balance has been carried to a reserve account. As the tariff rates are paid in the paper dollar—now so seriously depreciated—the Board has found it imperative to increase those rates. This has been done in some centres, and will be done in others. A reduction in the number of subscribers may therefore be expected, but the income will doubtless be maintained throughout, and probably considerably augmented, when the irritation generally created by changes of this kind may exhaust itself.

It will be observed that the capital outlay for the past year is £16,701, being £2,000 less than the previous year. This sum has been expended on the completion of the construction of the new trunk lines, and the usual preparation for connecting additional subscribers with the exchanges, the latter is now the only kind of expenditure on capital account. The 4,000 shares offered to the proprietors were all taken by them, and have all been paid for in full.

Messrs. Allsopp and Greenwood retire from the Board of Directors, and being eligible, offer themselves for re-election. The Auditor, Mr. Thomas A. Welton, also retires, and offers himself for re-election.

City and South London Railway Company.

The following is the report of the Directors, to be submitted to the half-yearly ordinary general meeting, to be held at Winchester House, E.C., on Tuesday, August 1st, at 12 o'clock noon:—

The receipts from all sources for the past half-year have amounted to £23,159. 6s. 3d., and the cost of working has been £14,964. 0s. 6d., leaving a profit of £8,195. 5s. 9d. Inclusive of the balance brought forward from December 31st last, the net revenue account shows an aggregate total of £9,073. 12s. 10d. After making provision for the debenture and debenture stock interest, amounting to £4,110. 13s. 10d., a balance remains available for dividend of £4,962. 19s. Out of this sum the Directors recommend the full dividend of 5 per cent. per annum be paid on the Preference shares, and that a dividend at the rate of ¾ per cent. per annum be paid upon the Consolidated Ordinary stock, leaving a balance of £898 to be carried forward to the next account.

The number of passengers conveyed during the six months ended June 30, 1893, exclusive of season ticket holders, was 3,146,656, showing an increase over the corresponding period of the previous year of 333,494. This increased traffic has been carried with immunity from any accident whatever, and the train service has been worked with unfailing regularity.

The Directors regret that the amount paid for local rates and taxes continues to show an increase.

The following table shows the number of passengers, exclusive of season ticket holders, carried since the opening of the railway in each half-year:—

Half-year.	Number of Passengers.	Receipts (including season tickets).
Ended December 31, 1890 (11 days) about	165,000	£1,568 3 9
„ June 30, 1891	2,412,343	19,403 6 9
„ December 31, 1891	2,749,055	19,798 16 6
„ June 30, 1892	2,813,162	20,931 4 2
„ December 31, 1892	3,217,602	22,002 17 5
„ June 30, 1893	3,146,656	22,458 6 9
Total since the opening of the Line ...	14,503,818	£106,162 15 4

The engineer certifies that the locomotives, rolling stock, generating plant, permanent way, and station buildings, have been efficiently maintained in good working condition. The new sidings at the Stockwell terminus are nearly completed, and will shortly be brought into use. The working of the traffic will be greatly facilitated by this much needed accommodation. To meet the requirements of the increasing traffic, some additional rolling stock is now in course of construction.

The Bill for the extension to Islington and other purposes has passed the House of Commons, and now awaits the Committee of the House of Lords, where it is unopposed. This Bill includes also the extension of time for the purchase of lands and construction of works under the Act of 1890 (Clapham Extension).

During the half-year £3,800 of terminable 5 per cent. Debenture Mortgage Bonds have been paid off and replaced by 4 per cent. Perpetual Debenture Stock. In order to provide at once some additional accommodation for passengers at the entrance to the King William-street station, the lease of the adjoining premises in Arthur-street East has been acquired on favourable terms, and the requisite alterations will shortly be commenced.

Liverpool Overhead Railway Company (Limited).

The Directors' report states that, owing to the delay in completing the electric signalling, only a ten minutes' service could be worked until May 22nd, since which date a five minutes' service has been established. They have pleasure in reporting that the main structure of the line has been completed, and that the electrical equipment has been working satisfactorily, the traffic being conducted with great regularity. The total number of passengers carried is 1,370,742, of which number 235,487 were first class, 956,922 second class, and 178,333 travelled with the cheap workmen's return tickets, which the Company have recently issued. A contract has been entered into with Messrs. Holme and King, of Liverpool for the extension of the railway to Crosby-road, Seaforth, from which considerable additional traffic is expected. The Directors have decided to ask the shareholders for authority to issue the remaining Preference capital of £45,000, but they do not anticipate that more than one-half will be required to provide funds for completion of the northern extension and for working capital. The accounts for the period during which the railway has been at work show that the gross receipts have been £12,352. 0s. 2d., and the working expenses £6,990. 5s. 2d., leaving a balance carried to net revenue account of £5,361. 15s. After providing £1,623. 5s. 11d. for interest on mortgage debentures from March 6th, and £122. 16s. 9d. for interest on calls paid in advance, &c., the balance available for dividend amounts to £3,644. 16s. 4d., out of which the Directors recommend a dividend of 5 per cent. per annum upon the Preference shares, which will absorb £351. 7s. 4d., leaving a balance of £3,293. 9s. to carry forward to next half-year.

Edison and Swan United Electric Light Company (Limited).

The following is the report of the Directors to be presented at the tenth annual meeting, to be held at the Cannon-street Hotel to-day (Friday), at 1 p.m.:—

The business of the Company for the year ended June 30, 1893, has resulted in a credit balance of £86,642. 5s. 1d. Of this £20,632. 19s. 5d. was distributed on March 14th last, as an interim payment on the "A" shares. The Directors recommend a further distribution of £22,976. 1s. 5d. on the "A" shares; and the whole of the cumulative Preference on the "A" shares having now been paid, of £3,534. 12s. on the "B" shares, the whole to be distributed accordance with the provisions of Clause 87

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of the Articles of Association. This will absorb £47,143. 12s. 10d., leaving £39,498. 12s. 3d., which the Directors have carried to the reserve fund, in accordance with Clause 89 of the Articles of Association. This will make the present distribution :—On the Ordinary "A" shares, 4s. 1d. per share ; on the fully-paid "A" shares allotted to the Swan United Company, 5s. 1d. per share ; on the fully-paid "A" shares allotted to the Edison Company, 6s. 8¾d. per share ; on the "B" shares (fully paid), 3s.—all free of income tax.

The Directors are developing the manufacturing branch of the business, and are making and supplying electrical instruments, fittings, and electrical appliances. They have re-opened the factory at Newcastle, and have opened depots for the sale of lamps and fittings in the principal towns in the provinces.

Major Flood Page and Mr. S. Bidwell, F.R.S., retire by rotation from the Board, and offer themselves for re-election. Messrs. Welton, Jones, and Co., the auditors, also offer themselves for re-election.

Crompton and Co (Limited).

The fifth report of the Directors of this Company for the year ended March 31st last, to be presented at the annual general meeting of the shareholders at the Cannon-street Hotel, E.C., on Monday, the 31st inst., at 3 o'clock, is issued, and is as follows :—

The accounts show that although the gross profits gives an increase upon the figures of the preceding year, the net results have been adversely affected by unusual and unforeseen expenditure. In January last the boilers at the Chelmsford Works suddenly gave out, and had to be replaced by others, and the year's working has had to bear a large share of the cost of this renewal and of the temporary arrangements necessitated thereby. It is highly improbable that any similar abnormal expenditure will recur in future years, but the Directors feel confident the shareholders will agree with them that it is right it should be charged to the year's account, even at the cost of a reduced dividend.

The orders in hand continue good, and negotiations for several important contracts are approaching completion.

The net profits for the year amount to £11,953. 7s. 4d., and after providing for debenture interest and payments set out in the revenue accounts, and deducting the interim dividends paid, there remains, with the £98. 10s. 2d. brought forward from last year, a balance available for dividend of £3,019. 12s. 8d. The Directors propose, after setting aside £750 as a provision for doubtful debts and contingencies, to declare a Preference dividend of 2s. 6d. per share, making, with the interim dividend already paid, 6 per cent. per annum on the Preference shares, to provide which the sum of £800 will be taken from the reserve fund.

Mr. H. H. J. W. Drummond retires from the Board of Directors by rotation, and offers himself for re-election, as do the auditors, Messrs. J. H. Duncan and Co.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1893, pages 320-348, *&c., &c.*]

DISTRICT MESSENGER COMPANY OF PARIS (LIMITED).—This Company was registered on the 22nd inst., with a capital of £200,000, divided into 80,000 Ordinary and 112,000 £7 per cent. Preference shares of £1 each, and 400 Founders' shares of £20 each, to adopt and carry into effect the agreement with Charles T. Russell, to engage and provide messengers, commissionaires, porters, and watchers, in connection with a system of electric call boxes, and to generate, purchase, supply, and apply electricity for any purpose.

ELECTRIC CONSTRUCTION COMPANY (LIMITED).—This Company was registered on the 20th inst., with a capital of £400,000, in £2 shares, of which 50,000 are Preference shares and the remainder Ordinary, to acquire and take over as a going concern the business, goodwill, and assets of the Electric Construction Corporation (Limited), to carry on and develop the said business, to enter into such arrangements as the Board may consider necessary for the taking over of the said concern, and to carry on in all or any of its branches the business of electrical and mechanical engineers, electricians, suppliers of electricity for the purposes of light, heat, sound, motion, force, &c., and manufacturers of, and dealers in, electrical appliances generally. The subscribers are :—

	Shares.
Sir Daniel Cooper, Bart., G.C.M.G., 6, De Vere-gardens, S.W.	1
Rt. Hon. David Plunket, Q.C., M.P., 12, Mandeville-place, W.	1
Emile Garcke, Queen-street-chambers, E.C.	1
Sir Henry C. Mance, C.I.E., Manora, Bedford	1
Thomas Parker, M.I.C.E, Newbridge, Wolverhampton	1
P. E. Beachcroft, 112, Portsdown-road, Maida Vale, W.	1
J. W. Barclay, 5, Clarendon-place, Hyde Park-gardens, W.	1

The first Directors are :—Sir Daniel Cooper, Bart., G.C.M.G., Sir Henry C. Mance, C.I.E., the Right Hon. David Plunket, Q.C., M.P., James W. Barclay, Philip E. Beachcroft, J. Irving Courtenay, James Pender, and Emile Garcke.

RUGBY SCHOOL ELECTRIC LIGHTING COMPANY (LIMITED).—This Company was registered on the 24th inst. with a capital of £5,500, divided into 110 shares of £50 each, to carry on at Rugby the business of an electric lighting company in all its branches, and to supply electricity for the lighting of the boarding houses and buildings connected with the Rugby School, as are occupied by persons holding an appointment in the school, or in connection therewith.

EASTBOURNE ELECTRIC LIGHT COMPANY (LIMITED).—The annual return, filed on May 19, 1893, shows that 1,017 Ordinary and 40 Preferred shares were subscribed for out of a total capital of £50,000, in £10 shares. Upon these shares the full amount has been called, and £10,570 paid.

EASTON AND ANDERSON (LIMITED).—The annual return of this Company, made up to May 13th, has been filed. The nominal capital is £250,000, divided into 2,060 Ordinary and 440 £5 per Cent. Preference shares of £100 each. All the Ordinary and 184 of the Preference shares have been taken up, of which the former were issued as fully paid. The full amounts have been called, and £18,400 paid on the Preference shares.

ELECTRICAL STANDARDISING, TESTING, AND TRAINING INSTITUTION (LIMITED).—In reply to official inquiries as to whether this Company should remain on the list of joint-stock concerns, Mr. P. A. Latham, of 15, St. Helen's-place, Bishopsgate-street, London, E.C., states that no issue of shares has been made, and that it is the wish of the seven signatories, who are the only shareholders, that the name of the Institution should be erased from the joint-stock register.

EVERED AND CO. (LIMITED).—The annual return of this Company, made up to April 13th, has been filed. Out of a nominal capital of £200,000, in £10 shares, 16,496 shares have been taken up. The full amount has been called on 6,744 shares, while a call of £7 per share has been made on the remaining 9,752 shares. The calls paid amount to £135,704.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended July 23rd were £761, as against £783 for the corresponding period of last year, being a decrease of £27. The total receipts for the half-year amount to £2,603, against £2,286 in the corresponding period of 1892, being an increase of £317.

CHARING CROSS AND STRAND ELECTRICITY SUPPLY CORPORATION (LIMITED).—The Directors of this Company have declared an interim dividend at the rate of £5 per cent. per annum on the Ordinary shares (30,000 of £5 each), which will be paid on August 15th.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The Directors have decided, subject to audit, to recommend the payment of the dividend at the rate of 10 per cent. per annum on the Preference shares, and a dividend at the rate of 4 per cent. per annum (free of income-tax) on the Ordinary shares ; both for the half-year ended June 30th last.

DISTRICT MESSENGER COMPANY OF PARIS (LIMITED).—The prospectus of this Company has been issued during the week. It is proposed to introduce the electric call system into France by organising a parent company to establish the system in Paris, and by then organising subsidiary companies for other towns. The capital of this Company, which is to acquire nearly the whole of the shares of the recently formed Parisian Company, is £200,000, in 12,000 £7 per cent. Preference and 80,000 Ordinary shares of £1 each, and 400 Founders' shares of £20 each, £30,000 of which (the prospectus states) has been already subscribed in Paris. The capital of the Company seems ridiculously large.

DUBLIN UNITED TRAMWAYS COMPANY.—The half-yearly meeting of this Company was held last week in Dublin, when the Chairman, in reply to a question as to whether some other motive-power could not be substituted for horses, said that there was a Bill before Parliament, which had every prospect of passing, for using electricity on the line between Dublin and Dalkey. It would not be on their line, but on the Southern District line. If the Bill were passed, and the result proved satisfactory, he was sure that it would show the Corporation that they ought to give their Company facilities to do the same thing, and on their part, they would be quite prepared when the time came, and when a generating station appeared to them to be properly working to adopt electricity.

ELECTRICAL ENGINEERING CORPORATION (LIMITED).—A meeting will be held at 58, Coleman-street, E.C., on August 22nd, at 12, to receive the liquidator's account of the winding-up.

MADRAS ELECTRIC TRAMWAYS COMPANY (LIMITED).—We mentioned in a recent number that this Company had been unsuccessful in obtaining an extension of time in which to obtain further capital, and that the concession had been cancelled The solicitors to the Company have made another appeal to the Municipal Commissioners and to the Government for an extension of six months in which to obtain a *bonâ fide* subscription of £75,000, failing which the solicitors admit that the shareholders would have no reasonable cause of complaint if the concession were cancelled.

ORIENTAL TELEPHONE AND ELECTRIC COMPANY (LIMITED).—The Directors of this Company have resolved to recommend to the shareholders, subject to final audit of the accounts, a dividend for the year ending December 31st last at the rate of 2½ per cent. on the entire paid-up capital of the Company. The dividend being payable only to the holders of the Ordinary shares, is equivalent to £3. 12s. 2d. per cent. on each share of 11s. paid, the same rate as paid for the previous year.

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WESTMINSTER ELECTRIC SUPPLY CORPORATION (LIMITED).—The Directors of this Corporation have declared an interim dividend for the half-year ended June 30th last at the rate of 3 per cent. per annum, payable on September 1st next to shareholders on the register on July 26th.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended July 21, 1893, after deducting 17½ per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,337.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 19.	Price Wednesday, July 26.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 26.	
						£ s. d.		Highest	Lowest
			TELEGRAPHS						
£1,134,640	Stock	12/6	Anglo-American	50½ 51½	49½ 50½	5 8 11	Jan. Apr., July, Oct.	49½	48
£2,932,680	Stock	25/0	Do. Preferred	94 95	93 94	5 17 0	" "	95	93½
£2,932,680	Stock	5/0	Do. Deferred	9½ 10	9½ 9¾	.. ..	.. ..	10	9½
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	99 102	99 102	3 18 5	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11¾ 12¼	11¾ 12¼	5 6 1	Mar., June, Oct., Dec.	12 1/16	12
£36,400	£100	5%	Do. 5 per Cent. Bonds	100 103	101 104	4 16 2	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	106 110	107 111	4 10 1	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	138 142	138 142	4 18 7	April and October	..	..
16,000	10	8/0	Cuba Submarine	11½ 12½	11½ 12½	6 8 0	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	18½ 19½	18½ 19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2⅞ 3⅛	2⅞ 3⅛	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅞ 12½	11⅞ 12	5 16 8	Jan., Apr., July, Oct.	12	11⅞
400,000	10	2/6	Eastern	15 15½	15 15½	4 5 3	" "	15½	15
70,000	10	6%	Do. 6 per Cent. Preference	16½ 17	16½ 17	3 10 7	" "	16 7/8	16⅞
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112 115	112 115	3 9 7	May and November	113⅜	..
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	108 111	4 10 1	February & August	..	..
250,000	10	2/6	Eastern Extension	15½ 15¾	15½ 15⅝	4 11 1	Jan., Apr., July, Oct.	15¾	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	113 116	113 116	3 9 0	February & August	114	113
£70 600	100	5%	Do. 5 p. c.(Austln. Gov. Sub.) Debs 1900	102 105	102 105	4 15 3	January and July	103	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb.,1900	101 104	101 104	4 16 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	102 105	102 105	3 16 2	February & August	..	..
£200,000	£25	..	Do. 4% Mauritius Sub. Debs. ..prem.	3¾ 4¼	3¼ 3¾	.. ..	May and November	..	..
180,227	10	2/3	Globe Telegraph and Trust	9¾ 10	9¾ 10	4 10 0	Jan., Apr., July, Oct.	10	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	15⅝ 15⅞	15⅝ 16⅛	3 16 2	" "	15⅞	15⅝
150,000	10	5/0	Great Northern	19½ 20	19½ 20	4 5 0	Jan., April, and July	20	..
£ 00,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105 108	105 108	4 12 7	March & September	107½	..
17,000	25	37/6	Indo-European	39 42	39 42	5 19 1	May and November	39½	..
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	6 13 4	" "	..	..
£100,000	100	6%	Do. 6 per Cent Debentures	107 110	107 110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs.	100 103	101 103	3 17 8	.. ..	..	..
11,802	8	4/0	Reuter's	5 6	4½ 5½	.. ..	April and October	4½	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6 per Cent.	119 124	118 123	4 17 7	" "	124	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July	..	..
£60,900	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	99	..
30,000	10	2/0	West Coast of America	3 4	3 4	.. ..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	97 101	97 101	7 18 5	June and December	..	..
88,321	10	6d.	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	.. ..	.. ..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 11	10½ 11	5 9 1	May and November	10⅞	10⅝
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9½ 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	105 108	105 108	4 12 7	June and December	..	..
64,242	15	4/6	Western and Brazilian	7¼ 7¾	7 7½	5 0 0	May and November	7½	7
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5⅞ 6¼	5⅞ 6½	.. ..	.. ..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1½ 2	1½ 2	.. ..	.. ..	1⅞	1⅝
£178,230	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106 109	106 109	5 10 1	February & August	..	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106 109	106 109	5 10 1	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120 125	120 125	5 12 0	May and November	..	..
£ 69,000	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	2 3	2 3	.. ..	.. ..	..	..
224,850	14/0	3½d.	Consolidated Telephone Const. & Maintenance	3/16 ¼	3/16 ¼	.. ..	May and November	..	..
220,000	£1	4¾d.	Oriental (11s. paid)	¼ ⅜	¼ ⅜	7 18 2	Yearly	..	..
458,867	5	2/6	National	4⅝ 5	4⅝ 4⅞	6 3 1	June and December	5	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14½ 15½	14½ 15½	3 18 8	" "	15½	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14½ 14¾	14½ 14¾	4 1 4	" "	..	..
90,950	5	6¾d.	Do. 5% Non-Cumulative 3rd Pref. (£5 paid)	5⅜ 5⅝	5⅜ 5⅝	4 8 11	.. ..	5⅜	5⅛
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	110 115	110 114	3 18 11	January and July	113½	112⅝
58,000	5	1/0	United River Plate	2 2½	2 2½	.. ..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	10¾ 11¼	10¾ 11¼	..	..	11	10⅞
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½ 13	12½ 13	..	..	12⅞	12½
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	5 5½	.. ..	..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
8,322	£5	..	House to House Electric	1½ 2½	.. ..	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	5⅜ 5⅝	.. ..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	6 6½	.. ..	..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4 1/8 4 1/16	4 1/8 4 1/16	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6⅝ 6⅞	6½ 6⅝	..	..	..	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6 6½	6 6½	2 17 2	..	6½	..
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102 105	102 105	4 15 3	June and December	102	..
6,452	£10	..	Notting Hill Electric	5 6	5 6	..	..	..	..
19,980	£5	9½%	St. James' and Pall Mall	7 7½	6½ 7	..	..	6⅞	..
20,000	£5	7%	Do. 7 per Cent. Preference	8 8½	8 8½	4 4 10	..	8	..
59,900	5	2/0	Westminster Electric Supply (fully paid)	5¼ 5⅜	5¼ 5⅜	3 0 10	..	5¼	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/6	Brush Electrical Engineering	2⅞ 3⅛	2⅞ 3⅛	..	..	3	2⅞
75,000	2	6%	Do. 6 per Cent. Preference	2⅛ 2⅜	2 2⅛	5 6 8	..	2⅛	2
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107 109	107 109	4 2 7	March & September	108½	108
20,000	5	3/6	Crompton and Co., 7 per Cent. Cumulative Pref.	5 5½	4⅜ 5½	6 1 9	January and July	..	..
12,139	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	1⅜ 2¼	..	..	..	..
49,900	10	12/0	Electric Construction	1⅜ 2¼	1⅜ 2¼	..	..	2	1⅞
91,195	2	10/0	Elmore's Patent Copper Depositing	¼ ½	¼ ½	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	..	1⅛	1
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	22 23	21½ 22½	5 11 1	February & August	22⅝	22
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	103½	..
11,334	£10	6/4	International Okonite Ordinary	2½ 3½	2½ 3½	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	4/0 5/0	4/0 5/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	1¾ 2¼	2 2½	15 19 0	May and November	2 1/16	1⅞
37,350	12	24/0	Telegraph Construction and Maintenance	33 35	33 35	5 2 10	March and July	34½	34
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	January and July	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	5%	City and South London Railway	35 37	35 37	1 13 9	May and November	..	..
37,500	£10	£10	Liverpool Overhead Railway	4⅜ 4⅝	4½ 4⅝	..	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 794.—Vol. XXXI. FRIDAY, AUGUST 4, 1893. PRICE FOURPENCE. *Annual Subscription (U.K.), 19/6*

NOTES.

The accounts of the Glasgow municipal electric lighting station for the first fifteen months of its existence show a loss of £1,773. The total outgoings between March 1, 1892, and May 31, 1893, amounted to £6,741, including £1,328 for depreciation, whilst the total incomings were £7,781. As, however, £2,812 has to be set aside for payment of interest on loans and redemption of capital, the apparent profit of £1,039 is converted into the above-mentioned deficit. With judicious management the operations of the next twelve month should result in, at least, an equilibrium.

We are glad to learn from a statement made by Mr. Mott at Tuesday's meeting of the shareholders of the City and South London Railway Company that the lighting of the carriages is engaging his attention, since we cannot but re-echo the remark of one of the shareholders that "it would be well if the lighting of the carriages could be somewhat improved." "A dim religious light" is all very well if it is steady and accompanied by "storied windows richly dight," but it is a nuisance when it is of an oscillatory character and its locus is a crowded car which is being shot through a dark tube. The semi-annual allusion to the "pure atmosphere, free from all noxious vapours," and the "even temperature, which is pleasant both in summer and winter" might also be taken as said until the facts and the epithets agree a little more closely. The atmosphere on the City and South London line is, of course, a decided improvement upon that which does duty on the Underground, but its purity and pleasantness are open to question. There is, we know, "some soul of goodness in things evil would men observingly distil it out," and even the so-called air on the Underground is, the Chairman of that railway assures us, conducive to longevity; but no amount of reiterated assertion will make the general public take kindly to either atmosphere.

The chief feature in connection with the Andreoli Ozoniser which we have had the opportunity of inspecting at Messrs. Allen and Hanbury's works is that there is very free circulation, so that a large volume of air is acted upon with free diffusion of the ozone as it is formed, and the ozonisation does not take place in a confined space as in most types of ozonisers. A very high efficiency in the proportion of ozone formed from atmospheric air is claimed by Mr. Andreoli, and from the construction of the apparatus one would expect this to be the case. Information is, however, wanting on the all-important question of the cost of production. That ozone is best produced by the silent discharge, and that a certain proportion of ozone in the air is beneficial to health, are two pretty well established facts, but the step from these two premises to the conclusion that the electrical production of ozone is synonimous with the cheap and efficient disinfection of our slums is not one which we are prepared to take on the evidence before us. What is required is a test made, say, on the air exhausted from the Brompton Hospital, where the volume of air treated, its composition before and after, and last, but not least, the cost of treatment, could be accurately tested.

There is a theoretical and there is a practical side to the researches of Dr. Duncan and his colleagues on the behaviour of the electric arc under pressure, which we publish this week. From a theoretical point of view the experiments are a step forward towards the solution of the vexed question as to the distribution of potential in the electric arc. There are two assumptions possible: that the distribution is entirely due to "ohmic" resistance of the carbon vapour, the specific properties of the vapour depending on the current density, and varying in a complex manner; or, that the distribution is split into a portion due to a counter electromotive force, and a remainder which is due to the resistance of a vapour the specific resistance of which is independent of the variations in the conditions of the arc, or which varies in a different manner from that required under the first assumption. Assuming the existence of this counter electromotive force, the experimenters have endeavoured to produce a series of conditions by which its elements could be determined; and they show grounds for believing that these elements consist in a large electromotive force due to carbon vapourisation, and a small electromotive force due to the thermo-electric effects of two carbon-carbon-vapour couples at different temperatures; both these elements being functions of the current and length of arc.

From the practical point of view, these experiments tend to confirm a suggestion which was made by Mr. E. T. Carter during the discussion which took place at the Institution of Electrical Engineers, in April, 1892, on "Notes on the Light of the Electric Arc." It was pointed out that the fact of placing the arc under increased pressure (not voltage) must increase the temperature and efficiency of the arc, as well as cause more light to be emitted from a given size of carbon. The curves

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given in Fig. 3 of Dr. DUNCAN'S Paper show that between 1 and 10 atmospheres there is a very considerable difference in the voltage at which a given current is maintained in the arc, and indicates that the candle-power and efficiency of the light would rise with the pressure. It will be seen, therefore, that the carbon-economising plan of running an arc *in vacuo*, which is favoured so much by certain inventors, would result in increasing the watts per candle owing to the low temperature the arc would have.

THE argument by which M. RICCARDO ARNÒ arrives at the conclusion, which will be found in our columns this week, that ebonite exerts a selective diathermancy which increases with the frequency of the radiation wave, is one which appears to be faultlessly logical; and the conclusion itself is not unimportant. By a series of well graduated experiments, in which the proportion of high-frequency waves is gradually reduced, a smaller and smaller percentage of energy is found to be transmitted through the sheet of ebonite; and this, apparently independently of the degree of polish and thickness of the material. It is not so easy, however, to discover from M. ARNÒ's investigations, what is the precise relation between a polished and an unpolished slab. M. ARNÒ has omitted to experiment upon slabs of equal thickness under these two conditions; and it is with some hesitation that we infer from the experiments he actually did make, that the polished state makes little or no difference to the relative diathermancy of different thicknesses. The point is well worth special investigation. In this connection it is interesting to notice the results of some researches on the transmission spectra of certain substances in the infra-red, by Prof. E. F. NICHOLS, which we find in the recent first number of the *Physical Review*. Comparing the diathermancy of plate glass with that of ebonite, when a series of wave-lengths in the infra-red were employed, the two curves of percentage transmission are, within the limits of probable error, found to be practically parallel.

IN DR. OLIVER LODGE'S letter last week he suggested that it was just possible that a universal medium which resists the motion of matter through it might really exist; but to avoid misapprehension, he now explains that he by no means implies that he believes in it as an actuality, and has good reasons for believing that etherial viscosity is really *nil*. It is a pity, after starting so interesting a discussion on Mr. OLIVER HEAVISIDE'S article, that the hypothesis of the two compensating forces should be so hastily withdrawn. The first point suggested by Mr. LARDEN in his letter to us this week has been already noticed in our last leading article. We there pointed out that, under the conditions suggested by Dr. LODGE, it appears that there would be an aberration moment on the sun. The energy dissipated by the motion of the planet through the viscous medium would *ex hypothesi* fail to retard this motion, and the only other source is the energy of the sun, or of the system. The effect of the curvature of the line of force, alluded to by Mr. HEAVISIDE this week, would be to reduce the rotational energy of the sun, or to set up perturbations which would reduce the total energy of the system.

MR. CONRAD COOKE'S letter to *The Times*, which will be found reprinted in our Notes, is but another instance of the lamentable muddle at Chicago. Mr. CONRAD COOKE'S intimate acquaintance with exhibitions, and his previous experience as juror, might have been of great service, but the Chicago Exhibition is, we fear, past saving. Two other gentlemen who have accepted nominations as jurymen have, we understand, not made a move westwards as yet. It might be rude to suggest that they are waiting for their fees before they start; perhaps they are only less enthusiastic about exhibitions than their unfortunate *confrère*.

Manchester.—The municipal electric lighting station was formally opened on Tuesday.

Hull.—The Local Government Board has sanctioned the borrowing of £10,000 for the purposes of electric lighting.

The Forthcoming Electrical Congress at Chicago.—Major-General Webber informs us that he has been appointed a delegate to the Electrical Congress at Chicago.

Fire at the Lyons Telephone Exchange.—The central telephone exchange at Lyons took fire on Saturday night. It was found necessary to cut the whole of the 1,250 connecting wires, and the telephone service of the city will consequently be interrupted for some time.

University College, Liverpool.—The 1893-94 session of this College commences on October 2nd. Complete courses of Instruction are arranged in (1) Civil Engineering; (2) Mechanical Engineering; (3) Electrical Engineering. For further particulars see our advertisement columns.

Institution of Electrical Engineers.—Among the Papers to be read during the next Session will be one on "The Electrical Transmission and Distribution of Power at Niagara Falls," by Prof. George Forbes; and one, "The Electric Lighting of the City of London," which has been promised by Sir David Salomons.

Electrical Bills in Parliament.—The Blackpool, St. Anne's and Lytham Tramways, and the Hampstead and St. Pancras and Charing Cross Railway Bills have passed Lord Morley's Committee of the House of Lords, the former having the "modified model clauses" inserted in it. On Monday the City and South London Railway, and the Barry Railway Bills were read a third time in the House of Lords.

Cement for Steam Pipes.—An American contemporary recommends the following recipe for a cement for stopping up leaky steam-pipe joints: five parts of plaster of Paris, five parts of yellow ochre, ten parts of litharge, five parts of red lead, and four parts of black oxide of manganese. These powders are mixed thoroughly, and a small amount of asbestos powder and boiled oil added. The cement will harden in from two to five hours.

Personal.—Mr. George A. Spratt has arrived at Gibraltar to take over the duties of superintendent at the Eastern Telegraph Company's quarters, vacant by the decease of Mr. De Sauty. Mr. Carey, for some time electrician on the cable ship John Pender, has also arrived, and acts as assistant-superintendent at the Gibraltar Station in place of Mr. F. Taylor, who left Gibraltar on Friday last for England, to relieve Mr. Spratt at the Company's Porthcurnow establishment.

Owen's College, Manchester.—The prize for the best essay on the Technical Applications of Electricity, has been awarded to Mr. J. R. Ashworth. This prize, of the value of £10, was given in the present year by Dr. Edward Hopkinson, the subject of the essay being "The Testing of the Efficiency of Dynamos and Motors."—The autumn session of this College commences on October 3rd. A special course on the technical applications of electricity has been arranged. Further particulars will be found in our advertisement columns.

Communication with Lightships.—In the House of Commons last week, Mr. Penrose Fitzgerald asked what steps had been taken to connect by telegraphic or telephonic communication

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with the shore any of the lightships, as recommended by the Royal Commission on December 8, 1892. Mr. Mundella stated that orders had been given to prepare the Kentish Knock Lightship for the reception of the cable without delay. The recommendations of the Commissioners were not being disregarded, but the Board of Trade were dealing with one case at a time.

Measuring the Efficiency of Transformers by their Heating. This workshop method, to which Mr. Mordey first called attention in his Paper on "Alternate Current Working," read before the Institution of Electrical Engineers in May, 1889, has been rediscovered by M. G. Claude, who describes it in *L'Industrie Electrique* for July 25. The difference is that whilst Mr. Mordey lays his thermometer directly on the iron, and covers it by a packing of cotton waste, M. Claude places his thermometer in the surrounding oil, thus restricting the method to oil transformers as well as to small transformers, but making it less liable to error.

The Government and the National Telephone Company.—In answer to a question put in the House of Commons on Monday night, Mr. Arnold Morley stated that an agreement to give effect to the policy decided upon by the Telegraph Act, 1892, and the Treasury Minute of May 23rd of that year, was in course of settlement with the National Telephone Company. In pursuance of the recommendations of the Select Committee, to which the Bill was referred, the agreement would be laid before Parliament, but the Committee were of opinion that the reponsibility for the details of the agreement should rest with the Government, and he did not propose, therefore, to lay it upon the table of the House before it was signed.

Hamburg.—The contract for the extension of the Hamburg electric light station and the distribution of electrical energy over the whole town has been given to Messrs. Schuckert and Co., of Nuremberg. Some 300 H.P. of the electric energy produced at the central station will be used for some tramway lines in the town. If this experiment proves satisfactory all the tramways of the town, requiring about 1,000 H.P., will be driven by electricity. It is also intended to connect the central railway station, which is in course of construction and which will require a large amount of current for light and power, with the central lighting station. Another 500 H.P. has to be provided for the cranes, which have been and will be erected in the harbour.

The City and Guilds of London Institute.—At a meeting of the Council, held on the 31st ult., the diploma of "Associate of the City and Guilds Institute" was awarded to the following third year students of the Central Institution:—Civil and Mechanical Engineering: K. W. Digby, G. A. Fry, G. H. Heelas, R. F. Krall, H. F. Robinson, A. E. H. Sonneborn, C. V. Drysdale, T. L. D. Hadwen, E. L. Joselin, H. C. Leake, R. D. T. Roe, and W. T. W. Sussman. Physics and Electrical Engineering: G. H. Ballie, W. A. Brodie, W. Casson, J. R. Dick, A. H. Finlay, E. E. Gunter, W. E. Miller, J. Barnard, R. B. Burrowes, W. R. Cooper, W. H. Everett, E. G. Fleming, T. Hemmant, N. Ward, and C. H. C. Woodhouse. Applied Chemistry: O. F. Russell.

Electric Heating.—It may be interesting to our readers to note that in carrying out the new method of electric heating discovered by Prof. Lagrange and M. Paul Hoho (see *The Electrician*, Vol. XXX., March 31st, p. 622) some care must be exercised in the method of working the switch. In a communication to the *Electrical World*, Mr. Jules Neher says that he has found it to be important to close the switch *before* immersing the metal rod, which forms the kathode, in the acidulated water. When this is done the hydrogen separates the metal from the liquid, and the arc which is produced across the gap heats the metal to whiteness; but if the switch is closed only after the metal is immersed, no arc is formed, and the current is expended merely in electrolysing the water.

Electric Lighting of the Halifax Flour Society's Mill.—At the last half-yearly meeting of the Halifax Flour Society the Secretary gave some information as to the saving the Society had effected by adopting the electric light. For 1892, he said, their total payments for gas and the electric lighting amounted to £122. 5s. 8d. In 1890, when they had no electric light, their gas account was £174. 0s. 1d. There was thus a difference of about £52. That, however, was not all, as, by putting in the electric light they effected a saving of their insurance of between £60 and £70 per annum. The Secretary added, that the figures were all the more significant when they took into consideration that, two years ago, they ground 100,048 quarters, and last year 127,150 quarters. The use of gas, he said, was now almost confined to their stables.

The Telephone Question at Manchester.—A Sub-Committee of the Highways Committee has just concluded a report on the subject of telephone wayleaves and wires. Having inspected the Sheffield underground system, and taking into consideration the objections entertained by the City Council to overhead wires, the Sub-Committee feel justified in recommending that facilities upon a fair basis and under proper conditions should be granted by the Corporation to telephone companies to place their wires underground. For the facilities thus accorded, it is suggested that the Corporation should make on the Company an annual charge in respect of each subscriber to the Manchester Telephone Exchange or Exchanges to the extent of 5s. per subscriber. The annual sum which the Corporation would receive at the present time upon this basis would amount to about £400.

Royal Societies Club.—A club with this title is about to be formed "at the suggestion of many gentlemen of influence and to meet an obvious want." The membership will be limited to Presidents, Members of Council, Fellows and Members of the principal Royal and Learned Societies of the British Empire, Academicians and Associates of the Royal Academies, together with the Presidents, Members of Convocation, Council and Professors of the Universities and various Royal Institutions. Premises have been secured at 63, St. James'-street. The present terms of subscription are six guineas for town members, three guineas for country members, and two guineas for foreign and colonial members. Amongst the founders of the Club are Sir David Salomons, Sir Frederick Abel, Sir John Pender, and Prof. Andrew Jamieson. The Club will be opened in October. Its temporary offices are at 3, Waterloo Place, Pall Mall.

The Reckoning.—"Men laugh and riot till the feast is o'er; then comes the reckoning, and—they laugh no more." The truth of this adage has dawned on our colonists in Australia, to the chagrin of, among many others, the Professors of Melbourne University. Regardless of the warning cries of political economists and financiers of experience, the Colonies have for many years persisted in a course of reckless and unproductive expenditure. Now bank after bank has been putting up the shutters, general depression reigns; and the University of Melbourne has been one of the scapegoats to the tune of £5,000 last year and an additional £3,000 this year deducted from the Government grant. The Professors have interviewed the Premier on the subject; and it is to be hoped that the course of technical education, which has just got a fair footing in the colonial Universities, will not be injured by such stringent measures.

The Blackening of Incandescent Lamp Bulbs.—The deterioration of incandescant lamps has often been prettily described as being due to a "bombardment" of electrified carbon molecules, but Prof. Elihu Thomson holds that in a well-exhausted lamp it is due almost entirely to prosaic evaporation. He assumes, of course, that the vacuum is so good that no visible discharge of electricity takes place, which would, naturally, wear out the filament by actual carriage of carbon. He thinks that it would be very strange if carbon maintained at so high a temperature in a vacuum did not evaporate. In a lamp a certain evaporation takes place which is independent of the size of the bulb, from which it follows that the coating will become much less as the bulb is greater in size, for the same deposit will yield a much thinner coating of carbon over a large surface than over a small one. If one lamp were made with the smallest possible bulb and another with a large bulb, the former might be rendered opaque, while the latter would only be slightly darkened, other conditions being the same.

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Lightning.—During a thunderstorm last week Cherkley Court, on Leatherhead Downs, was struck by lightning and set on fire. The flames soon spread, and within two hours the upper floor of the north-east wing was burnt out and the lower floors greatly damaged. The south-east wing was also seriously damaged. Several fire brigades turned out and prevented the total destruction of the mansion.——A telegram from Nashville, Tennessee, states that during a severe thunderstorm on Monday night, the circular building containing the cyclorama of the battle of Mission Ridge, was struck by lightning and completely ruined. The damage is estimated at $20,000.—— At about seven o'clock on Monday evening last a storm of considerable violence passed over Rotherham and district, and a farmer, of Thrybergh, near Rotherham, was struck by lightning and killed. He was engaged in haymaking, and was raking the hay up with a horse and rake when he was struck. During a thunderstorm which broke over Sprottau, in Silesia, the cavalry stables, where a number of soldiers were at work, was struck by lightning, and three men were killed.

Huddersfield.—On the 29th ult. the electric light station at Huddersfield was formally opened by the mayor. As a result of the inquiries of the municipal deputation, the high pressure alternating-current system was determined upon, and a contract was entered into with the Brush Company for the supply of plant and mains. The machinery already put in will provide for 9,000 8 c.p. lamps, but so great has been the demand for light that the plant is about to be doubled in capacity. The present plant comprises three Mordey alternators, having a total output of 250 kilowatts, driven from three compound vertical condensing steam engines, which are supplied with steam from four Babcock Wilcox boilers, having a total capacity of 800 H.P. The additional plant will comprise one 250-kilowatt alternator and steam engine of the same type as the others. Arrangements are made for running the alternators in parallel at 2,000 volts. The primary high-pressure mains are concentric, and have been manufactured by Messrs. Siemens Bros., and the low-pressure network is laid on the Callender-Webber system. There are four transformer sub-stations. The price charged for energy is 6d. per unit.

The Telephone Question at Glasgow.—From an able "official statement" in the *Glasgow Evening News*, it is evident that the National Telephone Company do not mean to allow the disadvantages of municipal telephony to be lost sight of. It cannot surely be contended, the Company argue, that a community of nearly 700,000 people should be taxed in order that a few thousand individuals, who are well able to pay a fair rate for their telephonic communication, should obtain the same at something less. No doubt municipal telephony would be a serious thing for the National Telephone Company, but it would not be ruinous. The fact that subscribers to a municipal exchange will not be able to communicate with other towns without paying an extra fee is also emphasised, though, of course, the same will probably be the case with subscribers to the National Telephone Company's exchange as soon as the trunk wires are transferred to the Post Office. There are two other points which it is thought have been lost sight of. The first is that the Postmaster-General will not give any license running beyond the time that is now fixed—namely, 18½ years, so that the whole capital expended by the Corporation would have to be redeemed in that time. The other point is this, that the Postmaster-General would never give a license to any person to establish a telephone exchange without paying the Post Office a royalty. Assuming that the municipal charge was £6 per annum, a 10 per cent. royalty on this would be 12s., which would be equal to a tax of 6s. per £1 (exclusive of income-tax) on the £2 profit which the Finance Committee show on paper per annum per subscriber, leaving them the sum of 28s. per subscriber to redeem the whole capital outlay.

Chicago Exhibition.—The following letter from Mr. Conrad Cooke appeared in *The Times* of Wednesday :—

SIR,—As one of the judges for the World's Fair, nominated by the Royal British Commission, and having just returned from Chicago, I think it may not be without interest to your readers if I give a view of the position of the technical judges from the judges' standpoint by relating my own experience. At the end of March last I was asked by one of the Royal Commissioners if I would be willing to go to Chicago to act there as judge in the section Electricity, and the sum of £200 was mentioned as probably the lowest amount that would be paid for expenses (the professional labour involved being gratuitous). To this I assented, and I was told that "the work of the judges shall commence not later than June 1, 1893." I accordingly made the necessary preparations and secured my passage so as to be in Chicago on that date. Some weeks later, however, I was officially informed that "the work of the judges will commence in the middle of June" and that "the sum of £150 will be assigned to each judge." On the day of my departure from London (obviously too late to make fresh arrangements), it was officially notified to me that "the work of the judges has been postponed from June 15th to July 1st." I arrived in Chicago on June 1st, resigned to an enforced delay of a month, but quite unprepared for a further postponement. In about three weeks, however, the authorities decided to postpone the work of the judges to the latter end of July or the beginning of August, so that it would be the end of September or the beginning of October before the work, under the most favourable conditions, could be finished. My professional engagements in Europe made it impossible for me to remain so long away, so I had no course left to me but to send my resignation to the Royal Commission. There were, however, other than personal reasons for resigning the position ; the conditions imposed upon the judges are, in my opinion, impossible to be fulfilled. According to the instructions, each judge is required to examine every individual object exhibited by every exhibitor in his section, and to make a report in writing, over his signature, thereon, stating his reasons for giving or withholding an award to that particular object ; and, moreover, he has, in addition, to prepare an abstract report upon each object he examines, and such abstracts are to be inscribed in the diploma to be presented to the exhibitor, while the full reports are to be published afterwards, and will form part of the literature of the exhibition. The fulfilment of such a condition would involve many months of the closest possible work. When it is considered that the duties of a judge necessitated an absence from England of some 18 weeks instead of 10 (as originally intimated), that one cannot live properly in Chicago for much less than £2 per diem, and that the prescribed conditions were, in my opinion, altogether impracticable, it will be seen that to resign the position was the only course open to me, although I understand it involves the loss of any allowance for expenses. I ask you to publish this letter, not with the view of ventilating any personal grievance, but with the object of placing on record the difficult position in which the judges at the World's Columbian Exposition have been placed by the want of proper consideration on the part of those in authority in the matter.

The Madras Electric Tramways.—The present position of the Madras Tramway question is a source of fruitful discussion in the columns of the local prints, says the *Indian Engineer*, and something like a deadlock seems to have been reached. The refusal of the Government of Madras to extend the time within which the Company is bound to find a certain amount of capital may just possibly bring matters to a conclusion—a conclusion which all who take interest in our material development must view with concern. Why shares taken by contractors in part payment should not be allowed for in a statement of share capital we cannot precisely see ; and we should like to know upon what logical grounds such a course is defended. That, however, is a question for lawyers to decide ; what more immediately concerns us is the possible wrecking of a scheme of engineering enterprise. For the Madras Electric Tramways Company (Limited) we have never had any great love, as former articles in these columns will have shown ; but it is greatly to be deplored that a quibble of the nature we have indicated should be allowed to prevent the supply of Madras with tramways. We are not informed that the position is without elements of hope, and we should be sorry to think that such was the case. Apart from the benefits that Madras may reasonably hope to gain from a system of tramways, the fact that electric traction was to be used for the first time in India in such a way lent additional interest to the operations of the Company. The project, too, of utilising town refuse for the generation of the necessary power is also something new to India, but in this particular we are inclined to think that the Company cut off a bigger chunk than it could well chew. The point of interest at the moment is, however, the action of the Madras Government ; if the enterprise is legitimate, then, in the name of all that is reasonable, let it have a fair show. If the present action is to be taken as meaning that after full investigation the Government is not convinced of the legitimacy of the undertaking, then we are sorry for the shareholders who have paid their four rupees per share. This we understand from the prospectus to be returnable in case of a partial allotment ; and after the expense the Company has already incurred, it will be interesting to see how repayment of application money is effected.

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A GRAVITATIONAL AND ELECTROMAGNETIC ANALOGY.—II.

BY OLIVER HEAVISIDE.

In my first article on this subject (*The Electrician*, July 14, 1893, p. 281), I partly assumed a knowledge on the part of the reader of my theory of convective currents of electrification ("Electrical Papers," Vol. II., p. 495 and after), and only very briefly mentioned the modified law of the inverse squares which is involved, viz., with a lateral concentration of the lines of force. The remarks of the Editor* and of Prof. Lodge† on gravitational aberration, lead me to point out now some of the consequences of the modified law which arises when we assume that the ether is the working agent in gravitational effects, and that it propagates disturbances at speed v in the manner supposed in my former article. There is, so far as I can see at present, no aberrational effect, but only a slight alteration in the intensity of force in different directions round a moving body considered as an attractor.

Thus, take the case of a big Sun and small Earth, of masses S and E, at distance r apart. Let f be the unmodified force of S on E,

thus
$$f=\frac{\mathrm{SE}}{4\pi r^2 c}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

using rational units in order to harmonise with the electromagnetic laws when rationally expressed. Also, let F be the modified force when the Sun is in motion at speed u through the ether. Then‡

$$\mathrm{F}=f\times\frac{1-s}{(1-s\sin^2\theta)^{\frac{5}{2}}}, \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where s is the small quantity u^2/v^2, and θ is the angle between r and the line of motion. ("Electrical Papers," Vol. II., pp. 495, 499).

Therefore, if the Sun is at rest, there is no disturbance of the Newtonian law, because its "field of force" is stationary. But if it has a motion through space, there is a slight weakening of the force in the line of motion, and a slight strengthening equatorially. The direction is still radial.

To show the size of the effect, let

$$\left.\begin{aligned} u&=3\times10^7 \text{ centim. per sec.}\\ v&=3\times10^{10} \text{ ,, ,, ,,}\end{aligned}\right\} \quad . \quad . \quad . \quad (3).$$

This value of u is not very different from the speed attributed to fast stars, and the value of v isthe speed of light itself.

So we have
$$s=\frac{u^2}{v^2}=\frac{1}{10^6}, \quad . \quad . \quad . \quad . \quad . \quad (4)$$

i.e., one millionth. All perturbing forces of the first order are, therefore, of the order of magnitude of only one-millionth of the full force, even when the speed of propagation is as small as that of light.

The simplest case is when the common motion of the Sun and Earth is perpendicular to the plane of the orbit. Then $\theta=\frac{1}{2}\pi$ all round the orbit, and

$$\mathrm{F}=f(1+\tfrac{1}{2}s), \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

showing an increase in the force of attraction of S on E of one two-millionth part, without alteration of direction or variation in the orbit.§

But when the common motion of the Sun and Earth is in their plane, θ varies from 0 to 2π in a revolution, so that the attraction on E, whilst towards the Sun's centre, always undergoes a periodic variation from

$$\mathrm{F}=f(1-s) \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

when $\theta=0$, to
$$\mathrm{F}=f(1+\tfrac{1}{2}s), \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

when $\theta=\frac{1}{2}\pi$. The extreme variation is, therefore, $\frac{3}{2}sf$, according to the data used. The result is a slight change in the shape of the orbit.

* *The Electrician*, July 14, p. 277, and July 28, p. 340.

† *The Electrician*, July 28, p. 347.

‡ This is the case of steady motion. There is no simple formulæ when the motion is unsteady.

§ But Prof. Lodge tells me that our own particular Sun is considered to move only 10·9 miles per second. This is stupendously slow. The size of S is reduced to about 1/360 part of that in the text, and the same applies to the corrections depending upon it.

But, to be consistent, having made v finite by certain suppositions, we should carry out the consequences more fully, and allow not merely for the change in the Newtonian law, as above, but for the force brought in by the finiteness of v which is analogous to the "electromagnetic force." This is very small truly, but so is the above change in the Newtonian law, and since they are of the same order of magnitude, we should also count the auxiliary force. Call it G. Then

$$\mathrm{G}=\mathrm{F}\times\frac{xqu}{v^2}\times \mathrm{V}\mathbf{q}_1\mathrm{V}\mathbf{r}_1\mathbf{u}_1, \quad . \quad . \quad . \quad . \quad (8)$$

where F is as before, in (2) above, q is the actual speed of the Earth (not the same as u), and in the third vectorial factor, $\mathbf{q}_1$, $\mathbf{u}_1$, and $\mathbf{r}_1$ are unit vectors drawn parallel to the direction of the Earth's motion, of the Sun's motion, and from the Sun to the Earth. We see at once that the order of magnitude cannot be greater than that of the departure of F from f, before considered, because u and q will be of the same order, at least when u is big. As for x, it is simply a numerical factor, which cannot exceed 1, and is probably $\frac{2}{3}$.

The simplest case is when the motion of the Sun is perpendicular to the orbit of the Earth. Then

$$\mathrm{G}=\mathrm{F}\times xs \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

gives the tensor or size of the auxiliary force. It is radial, but outwards, so that the result is merely to reduce the size of the previous correction, viz., the difference of F from f in the same motional circumstances.

But when the line of motion of Sun is in the plane of the orbit, the case is much more complicated. The force G is neither constant (for the same distance) nor radial, except in four positions, viz., two in the line of motion of the Sun, when the auxiliary force vanishes, and two when $\theta=\pm\frac{1}{2}\pi$, when it is greatest. But this force is still in the plane of the orbit, which is an important thing, and is, moreover, periodic, so that the tangential component is as much one way as the other in a period.

All we need expect, then, so far as I can see from the above considerations, are small perturbations due to the variation of the force of gravity in different directions, and to the auxiliary force. Of course, there will be numerous minor perturbations.

If variations of the force of the size considered above are too small to lead to observable perturbations of motion, then the striking conclusion is that the speed of gravity may even be the same as that of light. If they are observable, then, if existent, they should turn up, but if non-existent then the speed of gravity should be greater. Furthermore, it is to be observed that there may be other ways of expressing the propagation of gravity.

But I am mindful of the good old adage about the shoemaker and his last, and am, therefore, reluctant to make any more remarks about perturbations. The question of the ether in its gravitational aspect must be faced, however, and solved sooner or later, if it be possible. Perhaps, therefore, my suggestions may not be wholly useless.

CONDENSERS AND IDLE CURRENTS OF TRANSFORMERS.

BY PROF. PERRY, F.R.S., AND MILES WALKER.

Everybody knows that a condenser shunting the primary coil of a transformer causes a diminution in the effective current to be supplied when the secondary circuit is broken, that is, when there is no load upon the transformer. Although the mathematicians know all about this matter, there is some ignorance among ordinary students, and I think that the following numbers, calculated by Mr. Walker, will be found interesting.

The current to an unloaded transformer consists of the fundamental term of the same frequency as the primary voltage and there are other terms of three and five times the frequency. With these "other terms" the condenser has nothing to do; it cannot disguise them in any way; the total current always contains them. I shall not speak of them, as they may be imagined added on, and this saves trouble, for if the funda-

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mental term only is considered we may imagine the permeability constant; that is, that the primary circuit of an unloaded transformer has simply a constant self-induction.

If at any instant V is the primary voltage, R and L the resistance and self-induction in ohms and secohms, and if K is the capacity of the condenser in farads, the current in the coil is $\frac{V}{R+L\theta}$, and the current into the condenser is $K\theta V$, where θ stands for d/dt; so that the sum is $K\theta V + V/(R+L\theta)$. If $V = V_0 \sin pt$, the amplitude of the total current is

$$V_0\sqrt{\frac{(1-KLp^2)^2+K^2R^2p^2}{R^2+L^2p^2}},$$

and the *lag* of this total current behind the voltage is

$$\tan^{-1}\frac{Lp}{R} - \tan^{-1}\frac{KRp}{1-KLp^2}$$

To study this Mr. Walker has taken numbers from a Hedgehog transformer.

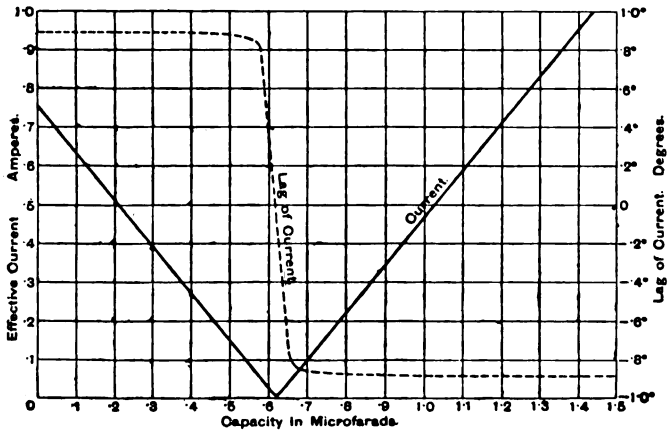
$$R = 24 \text{ ohms}, \quad L = 6{\cdot}23 \text{ secohms}, \quad p = 509,$$

or a frequency of about 81·1 per second.

The effective voltage (or $V_0 \div \sqrt{2}$) is 2,400 volts.

Then for certain values of K Mr. Walker has calculated values for the effective current in amperes and the lag in degrees.

These results have been plotted by Mr. Walker on squared paper. The current curve (*see* Figure), is a hyperbola which is



undistinguishable except just at the vertex, from two straight lines. The total current is a minimum when $K = L/(R^2+L^2p^2)$, in this case 0·618 microfarad; and the effect of the condenser has been to diminish the total current in the ratio of the resistance to the impedance. It is interesting on the curve to note how the great lag changes very suddenly into a great lead.

NOTES ON THE ELECTRIC ARC WITH SOME EXPERIMENTS ON THE ARC UNDER PRESSURE.

BY DR. LOUIS DUNCAN, A. J. ROWLAND, AND R. J. TODD.

Twenty-five years ago Edlund, to account for some of the phenomena which accompany the production of the electric arc, supposed that there existed in it a constant counter electromotive force, the flow of the current being opposed by this and by the ohmic resistance of the column of heated air and carbon vapour forming the arc. His formula was, $E = a + b\,c\,l$, where E is the potential difference at the terminals, a the counter E.M.F., b a constant, c the current, and l the length of the arc.

That this formula is not correct may be seen by an inspection of Table I, where the results are approximately represented by

$$E = a + \frac{b\,l}{c\cdot 7}.$$

Other formulæ have been used or suggested; for example, S. P. Thompson suggests $E = a + \frac{b\,l}{c}$, and Cross and Shepard employed $E = a\,c + b\,c\,l$.

In each case the formula fits pretty closely the experiments on which it is based, but does not agree with experiments made under different conditions. In fact, almost any results may be obtained by modifying the size and composition of the carbons, and it is of the greatest importance to find what part of the phenomenon is constant and what is variable. The existence of the counter E.M.F. in the arc—supposing it does exist—has been accounted for in two ways: by the vaporisation of the positive carbon, or by the thermo-electric effect of the carbon-carbon vapour couple which exists while the arc is burning. It seems to us that both of them must play a part in the phenomenon. As far as the vaporisation of the carbon is concerned, this represents a certain amount of energy taken from the current; therefore there must correspond to it a fall of potential a such that $a\,c$ represents the energy necessary to vaporise the carbon. The amount of carbon vaporised may be calculated from the electro-chemical equivalent of carbon, while the value of a could be calculated if we knew the energy required to vaporise one gramme of carbon. Any attempt to discover a counter E.M.F. due to this cause by looking for a reverse effect on suddenly stopping the direct current must fail, as the E.M.F. stops simultaneously with the direct current. Such an E.M.F., if it exists, must remain constant as long as the temperature of volatilisation of the carbon remains constant. If the temperature is raised—by pressure, for instance—this E.M.F. should increase. As far as the thermo-electric effect is concerned, there is no reasonable doubt of its existence, since we have a composite circuit with two junctions at widely-different temperatures. The temperature of the positive carbon is—under fixed conditions of pressure and composition of carbons—independent of the distance apart of the carbons and of the current, but the temperature of the negative carbon depends on both of these. It should be possible to detect this E.M.F. by shutting off the current and looking for a reverse effect. If we accept the vaporisation theory entirely, the counter E.M.F. would be independent of the length of arc and current; if we accept the thermo-electric theory we would look for a much more considerable lowering of the voltage in an alternating as compared with a continuous arc, than really exists. Neither supposition will, by itself, explain the phenomena.

The total potential difference, then, should, for given conditions, be represented by $E = a + f(l)\,f(c) + b\,f''(l)\,f'(c) +$. Before giving the results of our experiments on the arc under pressure, we wish to call attention to one of the most remarkable of the phenomena exhibited by the arc—a phenomenon which has been often observed, but for which we have seen no rational explanation.

By changing the current of the arc, using cored carbons $\frac{3}{8}$in. in diameter, we obtained the following results:—

Table I.—*Atmosphere pressure.*

Volts.	Amperes.	Apparent resistance.	Length in inches.
65·0	3·1	21·0	$\frac{1}{8}$
58·5	4·6	12·7	,,
55·0	6·14	8·96	,,
54·8	6·15	8·91	,,
52·5	7·7	6·82	,,
52·0	8·0	6·5	,,
49·2	9·82	5·01	,,
47·5	11·26	4·21	,,
46·5	12·75	3·65	,,

The only explanation admissible is this: the effective E.M.F. is equal to E, the applied E.M.F., minus the constant counter E.M.F. a due to the volatilisation of the carbons, minus the variable counter E.M.F. a' due to thermo-electric effects. The arc resistance would vary inversely as the current, provided, as might easily be the case, the section of the arc varied directly as the current.

We have, then, $c = \frac{(E-a)-a'}{\frac{b\,l}{c}}$,

a' being a function of c. If now we increase c we decrease a' and also $\frac{b\,l}{c}$, and E will decrease until the equation holds

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again. For instance, suppose

$$a = 30 \qquad a' = 15 \qquad c = 10 \qquad b\,l = 5,$$

then $$10 = \frac{E - 30 - 15}{\frac{5}{10}}, \text{ and } E = 15.$$

Now, suppose we increase c to 20 and a' changes to 10,

then $$20 = \frac{E - 30 - 10}{\frac{5}{20}}, \text{ and } E = 45.$$

It is evident that whether E increases or decreases depends, first, upon the decrease of a' with the increase of current, and, second, upon the variation of the arc resistance with the current. Both of these will depend on the size and composition of the carbons and their distance apart. So it is very easy to see why different observers have obtained different results and deduced entirely different formulæ.

With solid Carré carbons ¼in. diameter the results were different, the potential difference remaining, approximately, constant under wide variations of current.

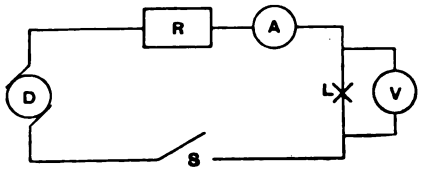

FIG. 1.

Arc under Pressure.—The apparatus used consisted of an iron cylinder, having stuffing boxes in the ends, through which the rods holding the carbons passed. The upper rod had a rack and pinion for adjusting the arc, and a scale for measuring its length. There was a pressure gauge on top. An air pump,

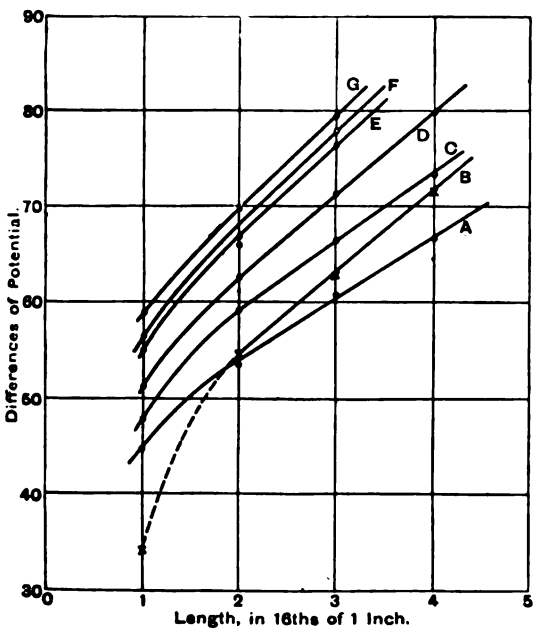

FIG. 2.—A, one atmosphere; B, vacuum; C, two atmospheres; D, four atmospheres; E, six atmospheres; F, eight atmospheres; G, ten atmospheres.

connected with the cylinder, was run by an engine. There were two glass windows in the cylinder at right angles to one another, so the carbon could be observed. A water jacket around the cylinder kept it cool. A shunt dynamo which we had somewhat overcompounded supplied the current, which, in most of the experiments, was kept constant at 6 amperes. The arrangement is shown in Fig. 1.

In determining zero readings on the scale, a high resistance, made of graphite, was thrown in series with R. This was so proportioned that when the carbons were apart the reading on the voltmeter was about one-third that of the dynamo. When the carbons touched, the voltmeter fell to zero. Each reading was repeated a number of times. No readings could be obtained while the air in the cylinder was being disturbed.

The results are given by the curves and tables. As c remained constant during the experiments, the value of a, considered as a constant, may be calculated from $E = a + b\,l\,f'(c)$. No matter what the function f' may be. Doing this we find the values of a given in Tables III. and IV. Leaving out values

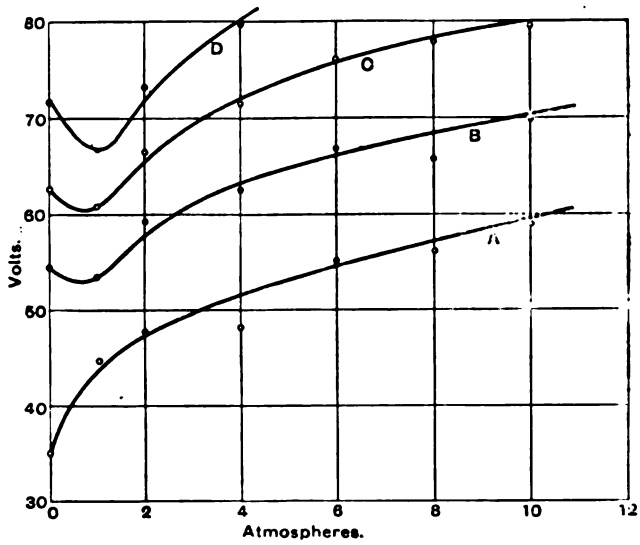

FIG. 3.—A, $\frac{1}{16}$in. length; B, ⅛in. length; C, $\frac{3}{16}$in. length; D, ¼in. length.

for the vacuum, which are low because of the very low reading taken for $\frac{1}{16}$in., we see that by combining the values for $\frac{1}{16}$in. with the ⅛in., $\frac{3}{16}$in., and ¼in. we get increasing values of a as the length increases, while if we take $\frac{1}{16}$in. and ⅛in., then ⅛in. and $\frac{3}{16}$in. and $\frac{3}{16}$in. and ¼in., the increase is more rapid.

Table II.—*Table of Average Volts, Constant Current 6 amperes.*

Length of arc in inches.	Atmospheres pressure.						
	Partial vacuum*	1	2	4	6	8	10
$\frac{1}{16}$	†34·19	44·88	47·75	48·5	55·07	56·2	59·0
⅛	54·47	53·48	59·28	62·55	66·82	65·87	69·9
$\frac{3}{16}$	62·76	60·75	66·33	71·4	76·23	77·75	79·5
¼	71·81	66·78	73·31	79·9			

* About 1in. of mercury. † Probably hissing arc.

Table III.

Pressure in atmospheres.	"Constant" a.		
	$\frac{1}{16}$" & ⅛" lengths.	$\frac{1}{16}$" & $\frac{3}{16}$" lengths.	$\frac{1}{16}$" & ¼" lengths.
Vacuum	13·91	19·90	21·65
1	36·28	36·94	37·88
2	35·94	38·48	39·43
4	34·5	36·2	38·0
6	43·32	44·49	.....
8	46·53	45·4	.....
10	48·1	48·5	.....

Table IV.

Pressure in atmospheres.	"Constant" a.		
	$\frac{1}{16}$" & ⅛" lengths.	⅛" & $\frac{3}{16}$" lengths.	$\frac{3}{16}$" & ¼ lengths.
Vacuum	13·91	37·89	35·61
1	36·28	38·94	42·66
2	35·94	45·18	45·36
4	34·50	44·85	45·90
6	43·32	48·0	.....
8	46·53	42·11	.....
10	48·1	50·7	.....

The tables show that a varies with l for all the pressure employed, for no function of l substituted for l in the formula will make

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a constant in the two tables. The absolute values of a, given in the tables, are probably not very accurate, as a small error in the voltages is considerably exaggerated in the results, especially in Table IV. So, in Table I., it is impossible to get any formula to fit the results. If we try to use $E = a + b\,l\,f(c)$, a seems to decrease as c increases, and the formula $E = a + \frac{bl}{c \cdot 7}$ is only approximately correct. The increase of E with the increased pressure is shown in Figs. 2 and 3.

The behaviour of the arc in partial vacuum is curious. The constant counter E.M.F. is probably lower, and the positive carbon is not so hot, but the negative carbon seems to cool proportionately faster than the positive, so the variable E.M.F. increases.

Looking at Tables II. and III. we see that the fall of potential due to ohmic resistance does not seem to increase in any regular way with the pressure.

Table V.

Length of arc. inches.	Atmospheres.	
	1	4
$\frac{1}{16}$	43·08	48·87
$\frac{1}{8}$	51·22	58·3
$\frac{3}{16}$	57·95	67·5
$\frac{1}{4}$	65·64	...

Table VI.

Atmospheres.	Values of a'.					
	$\frac{1}{16}$" & $\frac{1}{8}$" lengths.	$\frac{1}{16}$" & $\frac{3}{16}$" lengths.	$\frac{1}{16}$" & $\frac{1}{4}$" lengths.	$\frac{1}{16}$" & $\frac{1}{8}$" lengths.	$\frac{1}{8}$" & $\frac{3}{16}$" lengths.	$\frac{3}{16}$" & $\frac{1}{4}$" lengths.
1	34·94	35·64	35·56	34·94	37·76	34·88
4	39·44	39·55	...	39·44	39·9	...

The very small values of a, however, shown in Table III., are due to the low reading at $\frac{1}{16}$", where there was, in all probability, a hissing arc. If we take the values from readings at $\frac{1}{8}$ and $\frac{3}{16}$ and $\frac{1}{4}$, we find them closer to the values for the other pressures.

To determine the effect of the surrounding gas some experiments were tried in an atmosphere of carbon dioxide. The results are shown in Tables V. and VI. Although the values are a trifle lower than for air, they in general confirm the experiments of S. P. Thompson, who found that the arc was independent of the nature of the surrounding gas.

We conclude, then :—

1. That the counter E.M.F. of the arc is made up of two parts, an E.M.F. due to the volatilisation of the carbon, independent of the length of the arc, of the current, and of the size of the carbons, but dependent on the pressure; and a variable thermo-electric E.M.F. depending on the length of the arc, the current, the size of the carbons, and the pressure.

2. As the tendency of the arc is to increase in cross-section with the current, its resistance will decrease with the current.

3. The apparently anomalous decrease in E.M.F. with increase of current is probably due to the decrease of the thermo-electric counter E.M.F. caused by the heating of the negative carbon, together with the decrease of ohmic resistance referred to above.

4. There is a constant increase of potential difference with pressure above atmosphere for a given current and length of arc. Below one atmosphere the potential difference again increases.

5. The counter E.M.F. apparently increases with pressures above one atmosphere, while the ohmic resistance does not greatly change.

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POSSIBLE AND IMPOSSIBLE ECONOMIES IN THE UTILISATION OF ENERGY.*

BY PROF. ALEX. B. W. KENNEDY.

I myself regret very much, and I fear you will regret even more, that my subject to night is one which does not lend itself to illustration by example, or by experiment, and only to a small extent to illustration by diagram. It is essentially a matter of figures and of percentages, a matter involving the discussion of mechanical balance-sheets, and the estimation of prime costs in the department of Applied Physics. I feel sure that it is an important matter; I wish I could feel equally sure that I had the power to make it an interesting one.

The importance of the subject is not difficult to understand if you realise the enormous results—so large as to be even of national interest—which depend upon what can, and what cannot be done in the way of utilising energy. Economy in energy may mean wealth and prosperity to a nation; waste in energy may mean diminished commerce and general depression. We have always many advisers and counsellors with us; it is very far from easy to know, among the multitude of voices, who has wisdom, and who has only words. I wish to try to-night to give you some criteria by which to judge for yourself.

As an engineer, I am bound to take my stand at once on the firm basis that nothing is impossible except perpetual motion and the transmutation of metals. I suppose it would hardly be safe, indeed, to be too sure about the last, for one cannot help having an uneasy suspicion that Prof. Dewar will tell us shortly that down about 273 degrees everything is the same thing, or else is everything else, and that the difference between gold and lead, after all, is nothing more than a matter of thermo-dynamic function.

But at perpetual motion one can clearly make a safe stand, no matter how cold or how hot the physicists may make things for us. And in essence all the things which I shall have to characterise as *impossible* are really perpetual motions, or what is the same thing, attempts to get more out of something than there is in it; to get 21s. out of a sovereign without having any benevolent and foolish person standing by to provide the extra shilling.

It is familiar to even the least mechanical in this room that there are, in Nature, vast—I dare not say inexhaustible—sources from which we can obtain energy by certain more or less familiar processes. I say "obtain" energy, using the most familiar expression, but perhaps the word is not a very happy one. We require energy to light lamps, to smelt metals, to drive factories, to pull trains, but in no case do we obtain it ready made as we draw water from a well. There is plenty of it in existence, plenty to be had, but to get it in the form in which we want it we have always to transform it from some other form to the required one.

Notwithstanding the suggestion that has been made, that steam engines are unnecessary in the central station because the dynamos might so easily be driven by electricity, there is in every electric lighting station in this city, for instance, first a transformer of the natural energy of chemical combination into heat, then the transformation of heat energy into mechanical energy in a steam engine, then the transformation of the mechanical energy into electrical energy in the dynamos, and lastly the transformation of electrical energy into light, and also very largely back again into heat, in the lamp.

Often the transformations are not so numerous as in this case, but they always exist to some extent, and all the possibilities and impossibilities are practically related to some or other of these transformations. And with them are those fundamental facts which I will ask you to note.

1. Every transformation of energy is accompanied by some waste of energy.

2. Every transformation occurs in absolute accordance with certain phenomena which reproduce themselves so exactly that they have come to be called *physical laws.*

3. All the quantities which can appear in every transformation are as exactly measurable and have been as exactly measured as could be the temperature of this room, or the

* Lecture given at the Royal Institution, April 21, 1893.

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breadth of Albemarle-street. There is no room in these cases for guessing, or for dealing in mere wordy generalities, or speculations. A man who says that he is going to produce 25s. out of a sovereign would be laughed at. But he is no more talking nonsense than the man who proposes, for instance, to double the present efficiency of a pound of coal.

As to the first point, I use the expression waste rather than loss because the energy cannot well be said to be lost. A thing is, perhaps, incorrectly described as lost when one knows where it is, but if it has passed away uselessly it may at any rate be said to be wasted so far as the direct object of the transformation is concerned. The amount of energy lost in a transformation is measured by noting what is called the efficiency of the transformation, which is usuallly expressed as a percentage. A transformation with only one per cent. loss, for example, would be said to have an efficiency of 99 per cent., and so on. Perpetual motions are simply transformations of 100 per cent. efficiency; indeed, nowadays, one finds folk occasionally who are content with nothing less than 200 per cent. on paper.

In dealing with my second and third points, I am aware that I am trenching on much more difficult and delicate ground. "Known physical laws" (?) one may be, and for that matter one is, very frequently met with the objection that the phrase is unjustifiable, or, at any rate, inapplicable in these cases. All the laws, we are told, are not known; all the phenomena even are not known; discoveries may be made which will turn everything topsy-turvy at one stroke; and why, therefore, attempt, at the outset, to put foolish limitations to progress by saying that anything is impossible, merely because of such obstructives as physical laws. It is, alas, too true, that few things are completely known, at least I fully confess it for myself, and I believe there are those here whose knowledge of physical laws is incomparably greater than mine who would quite as freely admit the limitations of their knowledge.

But it is noticeable that this particular objection to saying that anything is impossible on account of our ignorance of what is possible, is, oddly enough, seldom thrown out by those who know most, even although, among other things, they well know their own ignorance. It seems always to be urged most strongly by those who know least. To the latter—to the good folk who dabble in physics and chemistry, and patents and syndicates—it is always possible to conceive that some new law or force, or source of energy, or what not, will rise, Minerva like, fully equipped for use in the universe, and particularly equipped for making their individual fortunes out of a casual suggestion or a random experiment. With them, also, it is always a first impulse to treat each new phenomenon as an exception, and to invent a new law on purpose for it, rather than to try if it can be explained in some hum-drum fashion by an old one.

I think it is not impossible to arrive at some understanding as to how far existing knowledge can be held to be final, and how far or in what directions it is provisional. I mean, of course, so far as affects our particular object of saying what is, and what is not, possible in one special direction.

It seems, perhaps, contradictory, but I think it is true, that our superstructure in physical knowledge is much more solid than our foundations. The position is indefensible structurally and ethically, but it actually appears to represent the facts. Our knowledge of the ultimate constitution of matter, and particularly of the ultimate constitution of "not-matter," cannot be said to be accurate as yet. Is this table a mass of atoms, turning on their own axes, and twisting round one another and themselves in inconceivable complexity of motion? Or is the most charming lady in this room a congeries of whirling vortex rings interlaced in tangles which no poet has yet attempted to unravel or describe? Are we pervaded by an ether, or do we pervade an ether, or are we, or is it under a pressure of millions of tons on the square inch? These are, no doubt, fundamental questions, and yet I doubt if even the most distinguished physicist living would venture to be very positive in his answers to them.

But higher up in the scale matters are different, and it is as well that we should remember that there are physical chemical facts and numbers that are just as fully established, although they refer to phenomena which we cannot entirely follow, as are the figures of the nautical almanack.

Let me take the combustion of coal as an example, with the external phenomena of which we are all familiar. Chemists have analysed the coal and know of what it consists; so much carbon, so much hydrogen, so much oxygen, and have measured for us that its elements in the combustion enter into various combinations, so that they can tell us exactly the maximum amount of heat energy which can be given out by the burning of a given weight of coal. Even apart from the extreme niceties of delicate laboratory work, we can probably say, without difficulty, within one or two per cent., the actual amount of heat energy in foot pounds which could be generated by the perfect combustion of any given 100 tons of coal lying in a yard. It may sound as if no one could, or would, deny this proposition. Yet I have often enough met people who were quite convinced that they possessed the secret by which an amount of heat equal to double this quantity could somehow be obtained. Our knowledge in this respect is quite independent of our ignorance of the ultimate nature of the coal

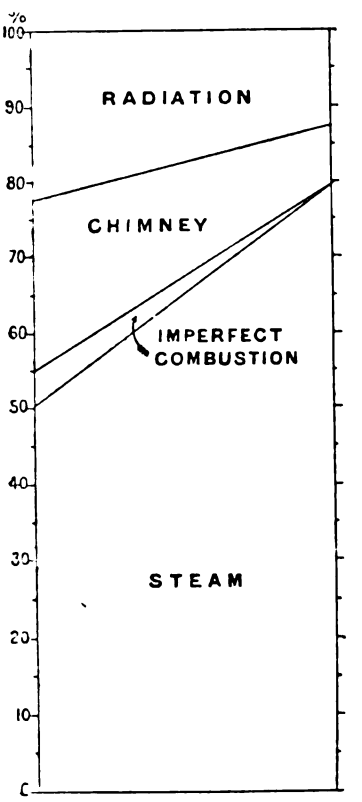

FIG. 1.

or the combustion. Assume, if you like, that hydrogen, like Homer, is not really hydrogen, but quite another element of the same name; assume carbon to be an allotropic form of oxygen; assume, if you please, that atoms are creatures of two dimensions, in series, connected by a little wire; but none of these assumptions, although they would be fundamental enough, will in any way invalidate our conclusions, or will enable us to get a single foot pound more of energy out of a ton of coal than we already know we can obtain. The facts we have to deal with are known, and independently of these fundamental general theories.

I have taken the phenomena of combustion as among those with which everyone is fairly familiar. Let us deal with it for a few minutes further in special illustration of my subject. Fig. 1 shows fairly accurately how far we have got in working at the efficiency of this kind of transformation. We start with a given amount of potential energy, known within very narrow limits, represented for us by a pound of coal with a sufficient weight of circumambient atmosphere. Let us represent this known amount of energy, as in the Figure, by 100 per cent. What becomes of all this if the coal be burnt in the furnace, say, of an

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ordinary boiler, and if we endeavour to utilise this combustion energy in the conversion of water into steam? On the left hand of my diagram you may see what often enough happens in every-day careless working; on the right hand you may see what happens in thoroughly good working with real care, but without any special apparatus. You will see that the amount of heat taken up by the steam varies from 50 to 80 per cent. of the whole heat; that a small amount, from 5 per cent. down to nothing, is lost in imperfect combustion, that is the formation of carbonic oxide; that a very much larger amount goes up the chimney, having been expended in heating the waste gases; and that finally another large amount is purely wasted, being lost in radiation, and otherwise. Now I ask you to notice particularly two things, first, looking at the right hand of the diagram, how much there is still possible. The efficiency of the process is about 80 per cent. The remaining 20 per cent. is all that can be saved. Of this some portion must go in heating the chimney gases. It is the price paid for the draught of the chimney. We must also lose something by radiation; this is inevitable. We cannot look, therefore, to any very astounding increase of economy in boiler work over the best that has been done. Secondly, I ask you to notice what an enormous amount is possible on the left-hand side of the diagram which is impossible on the right—impossible, that is, because it has already been attained. Half of our possibilities—indeed, far more than half our possibilities of improving up to the best—it is infinitely harder to improve up from the best.

When anyone tells us that he has invented something, or some method, by which one ton of coal goes as far as two, we may know for certain one of two things: either he has made a mistake (which is possible enough) or else his standard of comparison has been unfortunately chosen. No doubt any saving is possible, if only one starts with a bad enough example. But then that saving has already been made in fact, and it is misleading, to say the least of it, to claim it as novel, or as depending on any new discovery. Surely all discoverers must start from the very forefront of their predecessors' position. What magnificent musicians, or artists, or climbers, or engineers we might prove ourselves to be if only we might choose our standard far enough down, and ignore all the art or science of the last 500 years.

This sounds absurd enough, when put in this fashion, but hundreds of thousands of pounds have been thrown away on elaborate schemes which, at best, could no more than bring bad and careless practice up to a level passed every day in places where care and common sense has been expended on the same matter. Plenty of room exists for raising the general average efficiency of boiler work; for, if the average working all over the country were brought up to the standard of the best, there would, probably, be one-third less coal used every year than is now actually burnt. The possible economy is truly not unimportant, but I fear it can only be brought about by methods too common-place to please humanity, who are just as ready to call for signs and miracles as they were 2,000 years ago.

The process which we have discussed is, perhaps, really rather to be called a transference than a transformation; at any rate, it falls into the category of transformation whose theoretical maximum efficiency is 100 per cent., or, allowing for absolutely inevitable losses, perhaps 90 per cent. But with many processes with which we have to do, unfortunately, our maximum theoretical efficiency is only 25 per cent., and instead of attaining 80 per cent. even of this we are often happy enough with half as much.

In this class of processes lie great possibilities, so that it is no wonder they are attacked from all sides, but—alas!—there lie here, also, equally great impossibilities, and the way to success is strewn with the bones of failures.

It will be worth while spending a few minutes in clearing up the fundamental notions about this matter. Suppose we have two samples of ore, one of which contains 30 and one 20 per cent. of metal. It is clear, in the first place, that the most perfect process or apparatus can only get for us 30 or 20 per cent. respectively of the weight of our raw material.

In this sense the maximum theoretical efficiency of the reduction may be called 30 or 20 per cent., as the case may be. It is no use finding fault with the apparatus because it will not give us more metal; the fault is in nature, which refused a richer ore to begin with. The efficiency of the ore is low, so to speak, not the efficiency of the plant or of the process.

But in the reduction of ore, as in every other such process, perfection is unattainable, and no apparatus would obtain for us, on a commercial scale, quite 30, or quite 20 per cent. of the weight of the ore in metal. Here comes in the efficiency of production, as distinguished from the efficiency of the ore. Now it is clear that the efficiency of production has nothing in the nature of things to do with the richness of the ore. I may use Fig. 2 to illustrate this. It is divided, as before, into equal parts, representing percentages. The sloping line represents on the left the 20 per cent. of metal, and on the right the 30 per cent. Suppose it happened that the metal in the richer ore were combined in such a way as to be much more difficult to reduce than that in the purer ore, we might, after all, be able to get only 15 per cent. of metal out of each, as is indicated by the horizontal line. In this case the efficiency of reduction would be 50 per cent. in the rich and 75 per cent. in the poor ore. Or, going further, it might quite well happen that we

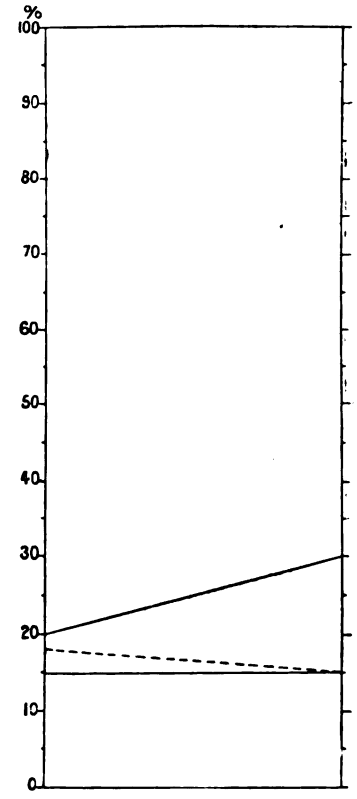

Fig. 2.

could get, say, 90 per cent. of the metal out of the poor, as against 50 per cent. out of the rich ore, as indicated by the dotted line in Fig. 2. In this case, the poorer ore would really pay us better than the other, for 90 per cent. of 20 per cent. is 18 per cent. of the whole weight, while 50 per cent. of 30 per cent. is only 15 per cent. of the whole weight.

I should like you clearly to bear in mind these double possibilities, for the secret of the whole matter is intimately connected with them. The efficiency of the ore—if one may so call the proportion of metal in it—has always a limiting value far less than unity, or 100 per cent. Only nuggets have an efficiency of 100 per cent., and these, I believe, only in novels. It is, moreover, fixed by nature, and not by us, so that we need not try to improve upon it except, of course, by looking out for the nuggets. The efficiency of the reducing process, on the other hand, is determined by us, and not by nature. Its theoretical maximum value is practically 100 per cent. How nearly this is reached in practical work is a matter of human skill in devising apparatus and carrying out processes.

I have used this quasi metallurgical illustration because, probably, it is more readily followed by those not familiar with

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the subject than a physical illustration. But I must now ask you to come back with me to the region of physics, and try to apply the example to physical work.

In the very great majority of instances the mechanical energy which we utilise is originally obtained from the heat of combustion, transferred to some liquid or gaseous body, and by it made to cause certain parts in a machine to move, and to do mechanical work for us.

Now the actual cycle of physical process, isothermal, adiabatic, isodynamic or what not, which the steam or air or gas may go through is often a very complicated one, sometimes so complicated that it is a matter of considerable difficulty to say beforehand exactly what the maximum theoretical efficiency is—that is, in terms of our former illustration, to say exactly how much metal the ore contains. We always, however, know two things about it: first, that it is always far less than 100 per cent.; second, that it cannot exceed—and in all practical cases must fall considerably short of—a certain known limiting value much less than 100 per cent. This limiting value is the very familiar one which is written $\frac{T_1 - T_2}{T_1}$. I may venture to illustrate its meaning in a very familiar way by Fig. 3.

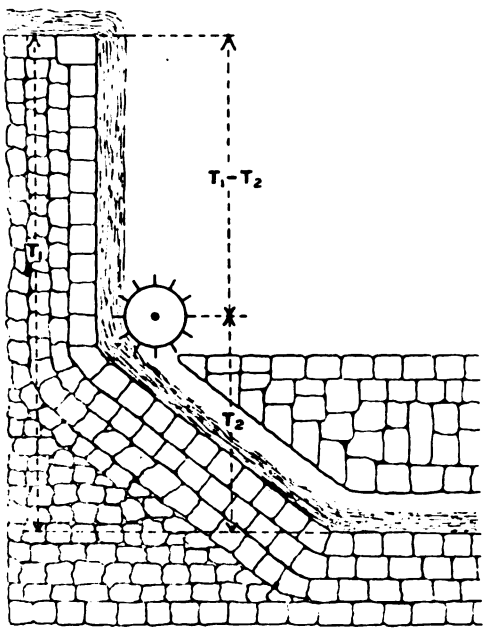


FIG. 3.

T_1 stands for the highest temperature measured above absolute zero, at which the working fluid receives heat. T_2 stands for the lowest temperature at which the fluid parts with its heat. The difference between the two temperatures, $T_1 - T_2$, is the working difference of temperature. In the Figure heights are substituted for temperatures, and $T_1 - T_2$ is the working head of water acting upon the imaginary water wheel. The value of the ratio which I have just given is always much less than unity, and must always be so, for the temperatures are measured from absolute zero, or, minus 273°C. The ratio is, in this way, always a proper fraction, which may be taken as representing what I have just been calling the richness, or the efficiency, of the ore. In the case of a modern steam engine its value is often about 30 per cent., in the case of a gas engine from 60 to 65 per cent.

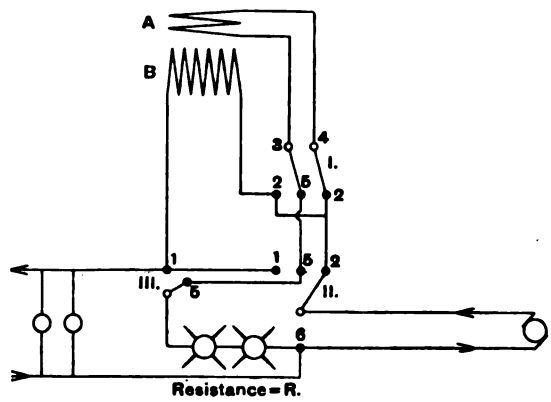
(To be continued.)

A COMMUTATOR ATTACHMENT FOR SIEMENS' DYNAMOMETER.*

The accompanying Figure shows a method, due to Behn-Eschenburg, of connecting a Siemens dynamometer to a circuit, whereby the current, the voltage, and the power may be successively measured. A and B are respectively the movable and fixed coils of the dynamometer, and I., II., and III. are switches or commutators for effecting the interchanges. To measure the current the switch I. is set as shown in the Figure, II. is set in contact with 5, and III. in contact with 5 also; this gives the value I for the current in the instrument. Then the switch III. is moved to 2, and the current I_1 is measured, the difference between the two currents being i. The power is, therefore, according to Fleming's method—

$$P = \frac{R}{2}(I_1^2 + I^2 - i^2),$$

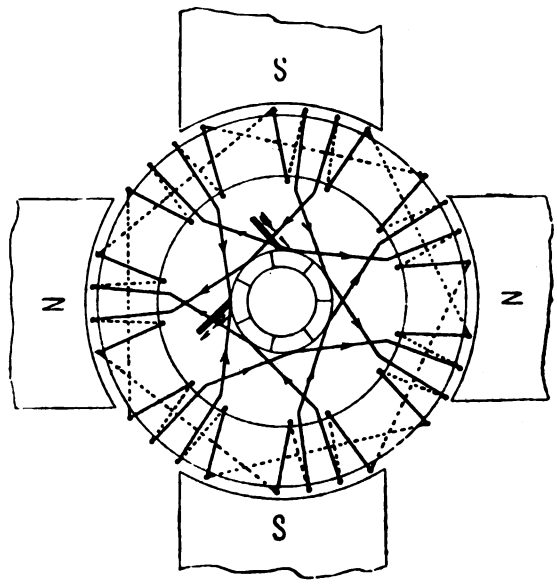
where R is the value of a non-inductive resistance, as shown. To transform the instrument into a voltmeter the switch II. is placed



in contact with 2, and III. in contact with 5. This measures the current i, which, multiplied by the resistance R, gives the voltage. The number of turns of wire on the movable coil is so small that for all values of the resistance R above 10 ohms the coefficient of self-induction of the coil is less than R/107. To measure the voltage the resistance R will, of course, be chosen, so that i is measurably within the range of the instrument.

A NEW ARMATURE-WINDING.

The accompanying figure shows a new kind of armature-winding, which has been designed by Mr. Ludwig Baumgart, and it is



intended chiefly for use with high-voltage four-pole machines. It is described in the *Elektrotechnische Zeitschrift* for June 9th, and is, as will be seen, a form intermediate between ring and drum forms, having twice as many wires outside as in; hence its value in high-pressure work. The author observes that for such uses machines may be conveniently made four-pole, and the addition of this armature, or one wound on a similar principle, enables full advantage to be taken of the increase in the number of poles in increasing the voltage. The armature has some of the advantages of the Gramme form, and is free from all patent rights.

* Abstract from *Elektrotechnische Zeitschrift*.

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The Electrician.

(The Oldest Electrical Journal.)

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny

Editorial, Publishing, and Printing Offices :

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.

Telephone No. 2714. *Telegrams :* "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co.*"

All Editorial letters to be addressed to the Editor.

All letters intended for insertion in "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as evidence of good faith. No notice whatever will be taken of anonymous communications.*

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SPECIALISING AND GENERALISING.

Among the eleven errors or "peccant humours" which are cited in the introduction to The Advancement of Learning, there is one which affirms "that after the distribution of particular arts and sciences men have abandoned universality, or *philosophia prima*, which cannot but cease and stop all progression. For no perfect discovery can be made upon a flat or level; neither is it possible to discover the more remote or deeper parts of any science if you stand but upon the level of the same science, and ascend not to a higher science." Regarding specialisation in science as a feature of the last fifteen or twenty years, it is strange to find that BACON saw, even in his time, before the foundations of modern science had been laid, a tendency to narrowness of work and thought. "For were it not better," he says, "for a man in a fair room to set up one great light, or branching candlestick of lights, than to go about with a small watch candle into every corner? . . . When you carry the light into one corner you darken the rest." Physical science being yet unfounded, it was his insight into human character rather than any inference from the absurdities of the schoolmen that led him to make this observation. There are many excuses for specialisation to-day. "The whole body of physick" is too wide for one man to master, and mere competition drives each man, by the principle of least resistance, to do either that which chance has thrown in his way, or that which by good luck he may be able to choose.

Specialists are the advance guard of the army of science, and after them come the rank and file with the "all-round men" in front. To specialists belong the exciting and difficult tasks of pioneering discovery, but an advance guard with no army behind it would be of little use. In its onward march

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science soon comes up with the points already reconnoitred by the scouts, and their work is absorbed and systematised, and takes its place in the general body of knowledge. Unfortunately everybody wants to be a pioneer, and since modern science tends to sub-division into a host of minor inquiries, it is greatly to be desired that general surveys of its various branches should be taken now and then by liberal-minded men. The "*philosophia prima*" Bacon explains to be "primitive or summary philosophy, as the main and common way, before we come where the ways part and divide themselves."

There was some very profitable *philosophia prima* of this kind in the discourse delivered by Prof. Kennedy before the Royal Institution in April last, and in our present issue will be found the first portion of this discourse. He discusses many examples of efficiencies and explains in a singularly clear manner the difference between available and unattainable economies. The specialist busies himself with new valve motions, automatic governors and lubricating devices, and ultimately attains an economy which, measured by coal consumption, might have been secured at a hundredth part of the cost by more careful lagging of a steam pipe, draining of a feed pump, or common-sense use of a damper. Much of the discourse is occupied with possibilities and impossibilities of the use of the steam engine; and he points out the fields in which further economies may profitably be sought, and those in which ignorant inventors, incautious enthusiasts, unscrupulous prospectus writers, or science correspondents of daily newspapers may be left to disport themselves; since none can exclude them.

OBITUARY.

OLIVER SMITH.

We regret to record the death of Mr. Oliver Smith. The deceased was born at Great Yarmouth in 1833, and joined the Gutta Percha Company in 1851, in which year he took a part in the manufacture of the 1851 Channel cable from Dover to Calais. In 1854, he left the Gutta Percha Company to enter the service of Messrs. Glass, Elliot and Co. at Greenwich, and from 1861 to 1864 assisted in laying cables from Malta to Alexandria, from Ireland to Wales, and from Sardinia to Sicily. He was engaged on the first Atlantic cable of 1858 on the "Agamemnon," and when the "Great Eastern" was chartered to take out the new Atlantic cable in 1865 he was in charge of the electrical department on board at Sheerness, during the shipping of the cable. He also accompanied the expedition of that year, as also those of the Atlantic cables of 1866 and 1869 as electrical assistant to his brother, the late Mr. Willoughby Smith. From this time to the end of his life he was in the service of the Telegraph Construction and Maintenance Company, during the greater part of which time he was engaged as electrician at Endesby's Wharf, Greenwich, although occasionally assisting in cable expeditions.

He will be well remembered by those who were on board the "Great Eastern" by his plentiful fund of good humour and anecdote, which helped to a large degree, especially during the trying task of recovering the 1865 cable in 1866, to pass away many a dreary hour. His mesmeric entertainments during these expeditions were also much appreciated by those on board. His loss is greatly regretted by a wide circle of friends and acquaintances in all parts of the world. Of late years he had been in failing health; in fact, he was never the same after the death (about seven years ago) of his only son, also in the service of the Telegraph Construction Company, who died suddenly on his way home from the successful laying of a cable in the Far East, in which expedition he had charge of the electrical department.

THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 343.)

Edison for a long time made a socket joint, which was electro-plated with copper. The deposit of copper extending a short distance along both the wire and the filament. This made a good joint both electrically and mechanically, but it was abandoned some years ago in favour of a simpler form. The most common form of joint is a simple socket with a deposit of carbon at the junction in place of the copper deposit used by Edison. A simpler form is that made by a deposit of carbon without any tube or socket. The most simple form of all, however, is where the joint is formed by a small lump of carbon paste. This was used by Edison after the electro-plated joint had been given up. The deposited carbon joint is the most satisfactory as a joint, and is consequently the most widely adopted, though it is more troublesome and expensive to make than the paste joint. The deposited joint is made by heating the junction of the filament and wires by electric current in an atmosphere of hydro-carbon gas, or under a hydrocarbon liquid. The gas is seldom used, as it is too slow. The liquid gives a much more rapid deposit, but has the disadvantage of getting more or less all over the carbon and wires, and must consequently be driven off again before the filament is sealed into the bulb.

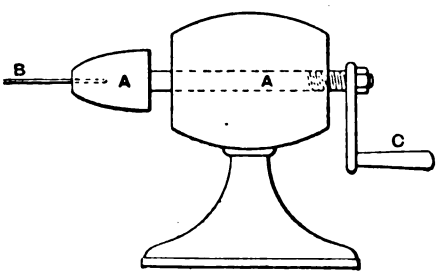

Fig. 9.

The first thing to be done towards making the joint is to prepare the platinum wires. The wire has first of all to be cut up into the lengths required. A deposited or paste joint can then be made without any further work on the platinum, but it is better to prepare the platinum in some way or cement will not have a good hold upon the wire. The plain wire is too smooth, and should be roughened or shaped so that the carbon cement has something to hold on by. The wire may be twisted into a spiral, forming thereby a socket into which the end of the filament is put. The spiral can be formed by twisting the wire with a machine like that in Fig. 9. A A is a spindle, with a needle B at one end and a handle C at the other. There is a screw thread on A which allows the needle to be rotated the same number of times, two or three usually, for each wire. The end of the platinum wire is inserted in a small hole close to the needle. The wire is held tightly, and the spindle rotated by the handle, thus twisting the wire two or three times round the needle. The wire is then slipped off the needle, straightened, and finished off with a small pair of pliers.

If a socket is required, it is better to make the tube form, which uses less platinum than the spiral. To make the tube, the wires are first flattened out for an eighth of an inch or so at the ends. This may be done by means of rollers, which may also be arranged to cut the wires at the same time. The wire being fed into the machine in a continuous length, is cut and flattened at one operation. The wires are then drawn through an ordinary wire draw-plate, which bends the flattened ends round into a tube. Before drawing through the plate, the flattened ends must be annealed by heating to redness in a Bunsen gas flame. If this is not done the

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flattened ends will be pulled off instead of being formed into a tube.

The filament is slipped into the socket, which is then squeezed upon it so as to hold it tightly. It is convenient to have the wires joined together by a bridge of glass before mounting in the socket, but it is not necessary.

If a butt or lap joint is to be made, the wires may be nicked near the end so as to form an indentation by which the deposit can hold on. An excellent way of making a butt joint is that which is used by the Edison-Swan Company. A small, flat head, like a pin-head, is formed on the end of the wires. The end of the filament is placed against the centre of this head, and carbon is deposited over the head and the end of the filament. As the carbon is deposited so as to completely cover up the head, it forms a very secure joint. Deposited carbon will always hold tightly to the filament. For filaments taking up to an ampere of current, platinum wire of 0·014in. diameter is generally used. The author has, however, known a lamp taking seven amperes to work perfectly well with this size of wire. For currents above one ampere larger wire should be used, and for more than five amperes several small wires are better than one large one.

The deposited carbon joint, as has already been mentioned, is made by heating parts of the wires and the filaments by a strong current of electricity in a hydrocarbon vapour, or

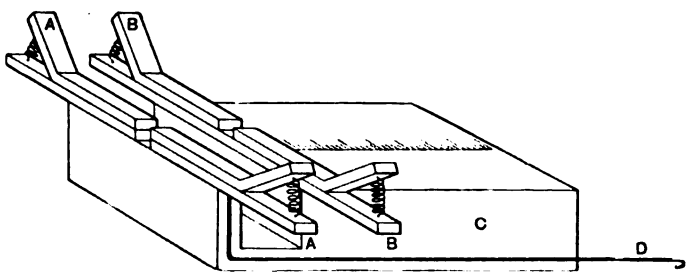

Fig. 10.

liquid. The hydrocarbon is decomposed by the heated wire and filament, and a deposit of carbon is the result. In order to make such a joint it is necessary to fix the wires and filament in a machine which will make the necessary electrical connections.

If a butt or a lap joint is to be made, the machine must be arranged so that the filament can be easily and quickly adjusted to its position opposite the platinum wires. For this purpose an instrument like that shown in Fig. 10 will answer the purpose.

There are two sets of spring contacts A A and B B, mounted on a wood block C, of which that part between the two sets of springs is cut away to the depth of about half an inch. The electrical connections are made to the spring contacts A A by means of the wire D and a corresponding wire on the other side of the instrument. The platinum wires are first clamped in A A, and the filament is then put into B B, so that its ends touch the ends of the platinum wires. The part which gets heated by the current is, of course, that between the two sets of clamps. The block is cut away to allow of a free circulation of the hydrocarbon.

When the deposit is obtained from a hydrocarbon vapour, the apparatus, with the filament and wires already placed in position, is hung on a support, which also conveys the current.

The liquid process is, however, more easily worked, and makes a more satisfactory joint. In this process the frame which holds the filament and platinum wires is hung on a support which also conveys the current, so that the part which is heated, and upon which the deposit is to be formed, is entirely below the surface of the liquid. Several filaments may be cemented at the same time, the frames being arranged in series, with a switch connected to each, so that any one of them may be cut out if necessary. It is more convenient to use a separate jar of liquid for each filament, though one large trough will answer the purpose. The jars are set in a metal or stoneware trough to catch any spillings of the liquid. It is also advisable that the whole of the bench at which the work is done be covered with zinc to prevent the wood from being soaked with the oil. An extinguisher to cover over the whole of the trough containing the pots of liquids may be provided in case of accident. There is, however, no danger from fire, unless very inflammable liquids are used. Any hydrocarbon liquid will produce a deposit on a carbon filament heated to redness below the surface of the liquid, though some liquids deposit very much more quickly than others. Vegetable oils, such as olive oil and linseed oil, produce a good deposit. They are, however, too viscous for use with very fine filaments, and the smoke which is produced has a bad smell. Turpentine deposits very rapidly, but the deposit is too soft. Benzoline or benzine rapidly deposit, but are too dangerous for ordinary use. Ether gives a rapid deposit, but, of course, cannot be used in the open. Mineral oils are generally used. The best kerosene oil gives a good and hard deposit, but is very slow. Crude petroleum, a black liquid containing mineral oils of various densities and flashing points, answers the purpose very well. A satisfactory liquid may be obtained by mixing one which deposits rapidly with one which does so slowly but gives a hard deposit; such a mixture, for instance, as four parts of best (high flashing point) kerosine to one part of turpentine. This mixture gives a sufficiently rapid and hard deposit, and is not dangerous to use. Even when the liquid has become very hot, a lighted match applied to the surface will be extinguished. While the deposit is going on a stream of dark smoke rises from the liquid. This smoke will burn as it bubbles up out of the liquid if it be lighted, but it can easily be blown out again. To obtain a proper deposit the joint is maintained at a bright red heat. There is no danger of firing the liquid so long as the joint is kept below the surface, and the current turned off before it is lifted out. The liquid may be fired by carelessness on the part of the operator. If, for instance, a joint breaks, as sometimes happens through excess of current when the depositing is going on, and so breaks the circuit, the operator may take out the filament and put in another, having forgotten to turn the switch off. As soon as the form with the new filament touches the contacts the joint will light up, and if it is not below the surface of the liquid, it will certainly set fire to the oil, if it be an inflammable one.

The strength of current used in making a joint is many times greater than the joint will ever be called upon to carry afterwards. In order to join a filament six mils in diameter to platinum wires of fourteen mils with tube sockets, the deposit to extend for a tenth of an inch along each leg of the filament, about twenty volts will be required to start the deposition, *i.e.*, to make the ends of the filament bright red-hot under the oil. As the deposition of carbon proceeds, the ends of the filament become rapidly duller. The thickness of the filament is increased, and, therefore, the cooling surface; while the resistance is at the same time diminished, and as there is a regulating resistance in the circuit, having a considerable resistance compared with that of the joint, the current rises only a very little. It is, therefore, necessary to cut out some of the regulating resistance and increase the current so as to keep the joint at a bright red heat. In this way the current will be gradually raised to at least twelve amperes before the joint is large enough, with a sufficient amount of deposit on the platinum. The volts will fall as the current is raised. With the best kerosene oil it will take ten minutes to make this joint. If the operation be hurried by turning up the current too fast, the joint will probably break, and both the filament and the wire will be spoiled by the arc which will be formed at the break. With one-fifth part of turpentine added to the kerosene, the time occupied can be safely reduced to one minute and yet produce a good hard joint.

The filaments may be flashed either before they are mounted or afterwards, or both before and after. Almost any hydrocarbon may be used, but for each one there will be certain conditions which will give the best results. Thus, one will work best if the filament be made very bright indeed, and another may only require a moderate temperature. One may require to be at a considerable pressure, while another must be much rarefied.

(To be continued.)

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THE LUMINIFEROUS ETHER.*

I intend to bring before you to-night a subject which the study of light has caused me to think a good deal about; I refer to the nature and properties of the so-called luminiferous ether. This subject is, in one respect, specially fascinating, scientifically considered. It lies, we may say, in an especial manner on the borderland between what is known and what is unknown. In the study of it it is quite conceivable that great discoveries may be made, and, in fact, great discoveries have already been made, and I may say even quite recently, and we do not at present know how much additional light on the system of Nature may be in store for the men of science; possibly even in the near future, possibly not until many generations have passed away. I will assume, as what is familiarly known to you all, and what is well established by methods into which I will not enter, that the heavenly bodies are at an immense distance from our earth. More especially is this the case with the fixed stars. Their distance is so enormous that even when we take as a base line, so to speak, the diameter of the earth's orbit, which we know to be about 184 millions of miles, the apparent displacement of the stars due to parallax is so minute as almost to elude our investigation. Nevertheless that distance is more or less accurately determined in the case of a few of the fixed stars. But the vast majority, as we have every reason to believe, are at such an enormous distance that even this method fails with them.

To give a conception of the immense distance of the fixed stars, I will assume as known that light travels at the rate of about 186,000 miles in one second, a rate which would carry it nearly eight times round and round the earth in that time; and yet if we take the star which, so far as we know, is our nearest neighbour, it would take three or four years for light from that star to reach the earth. Now, as we see the fixed stars there must be some link of connection between us and them in order that we should be able to perceive them. Probably all of you know that two theories have been put forward as to the nature of light, as to the nature accordingly of that connection of which I have spoken. According to one idea, light is a substance darted forth from the luminous body with an amazing velocity; according to the other, it consists in a change of state taking place, propagated through a medium, as it is called, intervening between the body from which the light proceeds and the eye of the observer. For a considerable time the first of these theories was that chiefly adopted by scientific men. It was that, as you know, which Newton himself adopted; and probably the *prestige* of his name had much to do with the favourable reception which for a long time it received. But more recent researches have so completely established the truth of the other view, and refuted the old doctrine of emissions, that it is now universally held by scientific men that light consists in an undulatory movement propagated in a medium existing in all the space through which light is capable of passing.

This necessity for filling all space, or, at least, such an inconceivably great extent of space, with a medium, the office of which, so far as was known in the first instance, was simply that of propagating light, was an obstacle for a time to the reception by the minds of some of the theory of undulations. Men had been in the habit of regarding the inter-planetary and inter-stellar space as a vacuum, and it seemed too great an assumption to fill all this supposed vacuous space with some kind of medium for the sole purpose of transmitting light. Notwithstanding, even long ago strong opinions were entertained to the effect that there must be something intervening between the different heavenly bodies. In a letter to Bentley, Newton expresses himself in very strong language to this effect: "That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance through a *vacuum*, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity that I believe that no man who has in philosophical matters a competent faculty of thinking, can ever fall into it. Gravity must be caused by an agent acting constantly according to certain fixed laws; but whether this agent be material or immaterial, I have left to the consideration of my readers."

What the nature of the connection between the earth and the sun, for example, may be whereby the sun is able to attract the earth and thereby keep it in its orbit—in other words, what the cause of gravitation may be—we do not know; for anything we know to the contrary, it may be connected with this intermediate medium or luminiferous ether. There are other offices, we believe, which this luminiferous ether fulfils, to which I shall have occasion to allude presently.

In connection with the necessity for filling such vast regions of space with this medium, a curious question naturally presents itself. We cannot conceive of space as other than infinite, but we habitually think of matter as occupying here or there limited portions of space, as, for example, the different heavenly bodies. The intervening space we commonly think of as a vacuum, and it is only the phenomena of light that led us in the first instance to think of it as filled with some kind of material. The question naturally presents itself to the mind—is this ether absolutely infinite like space? This is a question to which science can give no answer. Though we cannot help thinking of space as infinite, yet when we turn our thoughts to some material existing in space perhaps we more readily think of it as finite than infinite. But if the ether, however vast the portion of space over which it extends, be really limited, we can hardly fail to speculate what there may be outside its limits. Space there might be wholly vacuous, or possibly outside altogether this vast system of stars and ether there may be another system subject to the same laws, or subject to different laws, as the case may be, equally vast in extent; and if there be, then so far as we can gather from such phenomena as are open to our investigation, there can be no communication between that vast portion of space in part of which we live and an ideal system altogether outside the ether of which we have been speaking.

But the properties of the ether are no less remarkable than its vast or even possibly limitless extent. Matter of which our senses give us any cognisance is heavy, that is to say, it gravitates towards other matter which agrees with it in so far as being accessible to our senses. The question presents itself to the mind, does the other gravitate towards what we call ponderable matter? This is a question to which we are not able to give any positive scientific answer. If the ether be in some way or other connected with the cause of gravitation, it would seem more likely that it itself does not gravitate towards ponderable matter.

Again, we have very strong reason for believing that ponderable matter consists of ultimate molecules. First, that supposition accords in the simplest way with the laws of crystallography. Chemical laws afford still stronger confirmation of the hypothesis, through the atomic theory of Dalton, now universally accepted. Comparatively recently, the deduction of the fundamental property of gases from the kinetic theory, as it is called, affords strong additional confirmation of that view of the constitution of matter. Still more recently, the explanation which has been afforded by that theory of that most remarkable instrument, the radiometer of Crookes, has lent further confirmation in the same direction. None of these evidences apply to the ether, and accordingly we are left in doubt whether it too consists of ultimate molecules, or whether, on the other hand, it is continuous, as we cannot help conceiving space to be.

The undulatory theory of light was greatly promoted in the first instance by the known phenomena of sound, and the explanation which they received from the hydrodynamical theory. Accordingly, since sound, as we know, consists of an undulatory movement propagated through the air (or it may be through other media), and depending upon condensation and rarefraction, it was supposed naturally that light was propagated in a similar manner, by virtue of the forces brought into play by the condensation and rarefraction of the ether. But there is one whole class of phenomena which have actually no counterpart in those of sound; I refer to polarisation and double refraction.

The evidence for the truth of the theory of undulations as regards the phenomena of common light depends in great measure upon the fact of interference and the explanation which the theory gives of the complicated phenomena of diffraction. But in studying the interference of polarised light, additional phenomena presented themselves which ultimately pointed out that the vibrations with which we are concerned in the case of the ether, differ altogether in their character from those which belong to sound. The phenomena of the interference of polarised light prove incontestably that there exists in light an element of some kind having relation to directions transverse to that of propagation, and admitting of composition and resolution in a plane perpendicular to the direction of transmission according to the very same laws as those of the composition and resolution of forces, or velocities, or displacements in such a plane. This requires us to attribute to the ether a constitution altogether different from that of air. It points out the existence of a sort of elasticity whereby the ether tends to check the gliding of one layer over another. Have we no example of such a force in the case of ponderable matter? We have. We know that an elastic solid, which for simplicity I will suppose to be uncrystalline, and alike in all directions, has two kinds of elasticity, by one of which it, like air, tends to resist compression and rarefraction; while by the other it tends to resist a continuous gliding of one portion over another, and to restore itself to its primitive state if such a gliding has taken place. There is no direct relation between the magnitude of these two kinds of elasticity, and in the case of an elastic solid, such as jelly, the resistance to compression is enormously great, compared to the resistance to a gliding displacement.

If we assume that in the ether there is really an elasticity tending to restore it to its primitive condition when one layer tends to

* Presidential Address by Sir G. C. Stokes, delivered before the Victoria Institute.

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glide over another, an elasticity which it appears to be absolutely necessary to admit in order to account for the observed laws of interference of polarised light, the question arises, Can we thereby explain double refraction?

The earliest attempts to explain it in accordance with the theory of transverse vibrations were made by attributing to the ether a molecular constitution more or less analogous to that which we believe to exist in ponderable matter. Following out speculations founded upon that view, the celebrated Fresnel was led to the discovery of the actual laws of double refraction; the theory, however, which he gave was by no means complete, inasmuch as the results were not rigorously deduced from the premises. Cauchy and Neumann, independently and about simultaneously, took up Fresnel's view of the constitution of the ether, and applied it to explain the laws of double refraction. In their theory the conclusions arrived at were rigorously derived from the premises; but the results did not altogether agree with observation—that is to say, although they could by the adoption of certain suppositions be forced into a near accordance with the observed laws of double refraction, yet they pointed out the necessity of the existence of other phenomena which were belied by observation. Our own countryman, Green, was the first to deduce Fresnel's laws from a rigorous dynamical theory, although nearly simultaneously MacCullagh arrived at a theory in some respects similar, though on the whole I think less satisfactory.

Still all these theories followed pretty closely the analogy of ponderable matter; and at least in the first three mentioned the ether was even imagined to consist of discrete molecules, acting on one another like the bodies of the solar system regarded as points, by forces in the direction of the joining line, and varying as some function of the distance. I have already quoted the very strong language in which Newton rejected the idea of the heavenly bodies acting on one another across intervening spaces which were absolutely void. But the conception has nothing to do with the magnitude of the intervening spaces; and the conception of action at a distance across an intervening space which is absolutely void, is not a bit easier when the space in question is merely that separating two adjacent molecules, when the ether is thought of as consisting of discrete molecules, than it is when the space is that separating two bodies of the solar system, though in this latter case it may amount to many millions of miles. If the ether be in some unknown manner the link of connection whereby two heavenly bodies are enabled to exert on one another the attraction of gravitation, then, according to the hypothetical constitution of the ether that we have been considering, we seem compelled to invent an ether of the second order, so to speak, to form a link of connection between two separate molecules of the luminiferous ether. But since the nature of the ether is so very different, as it must be, from that of ponderable matter, it may be that the true theory must proceed upon lines in which our previous conceptions, derived from the study of ponderable matter, are in great measure departed from.

If we think of the ether as a sort of gigantic jelly, we can hardly imagine but that it would more or less resist the passage of the heavenly bodies—the planets for instance—through it. Yet there appears to be no certain indication of any such resistance. It has been observed indeed in the case of Encke's comet, that at successive revolutions the comet returned to its perihelion a little before the calculated time. This would be accounted for by the supposition that it experienced a certain amount of resistance from the ether. Although at first sight we might be disposed to say that such a resistance would retard perihelion passage, yet the fact that it would accelerate it becomes easily intelligible, if we consider that the resistance experienced would tend to check its motion, and so prevent it from getting away so far from the sun at aphelion, and would consequently bring it more nearly into the condition of a planet circulating round the sun in a smaller orbit.

Many years ago I asked the highest authority in this country on physical astronomy, the late Prof. Adams, what he thought of the evidence afforded by Encke's comet for the existence of a retarding force, such as might arise from the ether. He said to me that he thought we did not know enough as to whether there might not possibly be a planet or planets within the orbit of Mercury which would account for it in a different way. But quite independently of such a supposition, it is worthy of note that the remarkable phenomena presented by the tails of comets render it by no means unlikely that even without the presence of a resisting medium, and without the disturbing force arising from the attraction of an unknown planet situated so near to the sun as not to have been seen hitherto, the motion of the head of a comet might not be quite the same as that of a simple body representing the nucleus, and being subject to the gravitation of the sun and planets and nothing else. It appears that the tails consist of some kind of matter driven from the comet with an enormous velocity by a sort of repulsion emanating from the sun. If the nucleus loses in this manner at each perihelion passage an exceedingly small portion of its mass, which is repelled from the sun, it is possible that the residue may experience an attraction towards the sun over and above that due to gravitation, and that possibly this may be the cause of the observed acceleration in the time of passing perihelion even though there be no resistance on the part of the ether. So that the question of resistance or no resistance must be left an open one.

The supposition that the ether would resist in this manner a body moving through it is derived from what we observe in the case of solids moving through fluids, liquid or gaseous, as the case may be. In ordinary cases of resistance, the main representative of the work apparently lost in propelling the solid is in the first instance the molecular kinetic energy of the trail of eddies in the wake. The formation of these eddies is, however, an indirect effect of the internal friction, or if we prefer the term viscosity, of the fluid. Now the viscosity of gases has been explained on the kinetic theory of gases, and in the case of a liquid we cannot well doubt that it is connected with the constitution of the substance as not being absolutely continuous but molecular. But if the ether be either non-molecular or molecular in some totally different sense from ponderable matter, we cannot with safety infer that the motion of a solid through it necessarily implies resistance.

The luminiferous ether touches on another mysterious agent, the nature of which is unknown, although its laws are in many respects known, and it is applied to the every-day wants of life, and its applications are even regulated by Acts of Parliament; I allude to electricity. I said that the nature of electricity is unknown. More than forty years ago I was sitting at dinner beside the illustrious Faraday, and I said to him that I thought a great step would have been made if we could say of electricity something analogous to what we say of light, when we affirm that light consists of undulations; and he said to me that he thought we were a long way off that at present. But, as I said, relations have recently been discovered between light and electricity which lead us to believe that the latter is most closely connected with the luminiferous ether.

Clerk-Maxwell showed that the ratio of two electrical constants which are capable of being determined by laboratory experiments, and which are of such a nature that that ratio expresses a velocity, agrees with remarkable accuracy with the known velocity of light. This formed the starting-point of the electromagnetic theory of light which is so closely associated with the name of Maxwell.

According to this idea, light may be looked on as the propagation of an electromagnetic disturbance, whatever the appropriate idea of such a thing may actually be. The theory has quite recently received remarkable confirmation by the investigations of Hertz, who has shown that what are incontestably electromagnetic disturbances, and are investigated by purely electrical means, exhibit some of the fundamental phenomena of light, such, for example, as interference and polarisation. It appears that these electromagnetic waves are strictly of a similar nature to the waves of light, though there is an enormous difference in the scale of wave-lengths, which in the case of light range about the one-fifty thousandth part of an inch, while the electromagnetic waves which have been investigated by purely electrical methods range from a few inches to many yards.

The Prevention of Sparking.—A recent number of *L'Electricien* describes some of the means which may be adopted for diminishing sparking at the brushes of continuous current dynamos. The first instalment of this article deals only with closed-coil armatures. The writer, M. Rechniewsky, asserts that in the best of dynamos of this class it is necessary to shift the brushes in order to prevent sparking when the current varies. This, however, is only correct as far as it relates to continuous current dynamos such as are to be found in our best central stations when the variation of current is very large indeed; for moderate variations the change in the resulting field and the alteration of lead are negligible. The writer illustrates what may be supposed to take place in a general way when an armature section is commutated, by means of a series of diagrams dealing with the three cases of—too early, too late, and non-sparking commutation. These diagrams, which are far from representing the details of what actually takes place in the commutated section, are, nevertheless, likely to assist a student in getting at the main idea correctly. The latter portion of the first instalment discusses the question of sparking from the dynamo characteristic point of view, and compares the effect of a given change of current in a Pacinotti-wound armature with that in the armatures without projecting teeth.

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ON THE TRANSPARENCY OF EBONITE.*

BY RICCARDO ARNÒ.

The transmitting power of thin sheets of ebonite was determined for heat rays due to six different sources, by means of a thermopile and a Thomson astatic mirror galvanometer. The sources were :— 1. An incandescent lamp fed by a battery of accumulators, with the interposition of a plate of ordinary glass 7 mm. thick. 2. The same incandescent lamp without the glass plate. 3. A Locatelli lamp. 4. A spiral of platinum made incandescent by means of a Bunsen burner. 5. An iron plate heated by an alcohol lamp. 6. The smoked face of a Leslie cube containing boiling water.

Three films of ebonite were experimented upon, two of them with a bright surface, and thicknesses 0·12mm. and 0·52mm. respectively, and a third 0·44mm. thick, with a dull surface. Calling 100 the amount of heat given out by each source, the amounts transmitted are given by the following table :—

Thickness of ebonite film. mm.	Diathermanous power for the different sources.					
	1.	2.	3.	4.	5.	6.
0·12	75	68	62	54	43	31
0·52	62	51	40	30	21	12
0·44	44	37	30	23	17	12

These data lead to the following conclusions :—

1. Ebonite in thin films is not equally transparent for all the radiations of obscure heat.

2. Its transparency for such radiations increases with their refrangibility and is greatest for those of smallest wave length. Its diathermanous power is, in fact, greatest when the source of heat (in these experiments an incandescent lamp screened by a glass plate) is one that sends out heat radiations for the most part of small wave-length. It must here be remarked that, if the film is thin enough, it is also transparent as regards the less refrangible luminous rays, as was verified for the specimen of thickness 0·12mm., across which red light was able to pass when the source was very bright.

3. Ebonite is nearly opaque for heat radiations of low refrangibility, such as those of the smoked face of a Leslie cube at 100deg.

4. As in the case of other diathermanous bodies, the transmitting power of ebonite increases as the brightness of the surfaces increases or the thickness diminishes.

According to Maxwell's electromagnetic theory of light we must, therefore, hold that ebonite, which is a bad conductor for continuous currents, for ordinary alternating currents, and for alternating currents of a frequency equal to that of Hertzian electromagnetic oscillations, is conducting for electromagnetic oscillations having a frequency of the order of magnitude of those corresponding to obscure heat radiations of great wave length, and again acquires the properties of dielectric bodies for obscure oscillations of wave-length nearest to that of red light, to become finally again a good conductor for luminous oscillations.

* From the Atti della R. Accademia delle Scienze di Torino, June, 1893.

THE UNIVERSAL DYNAMO.

Teachers of technical electricity who are desirous that their laboratories shall attain a maximum of efficiency and scope, notwithstanding the tendency of funds towards a microscopic minimum, must sometimes be at almost their wits' ends because of the increasing multiplicity of machinery used in modern electrical engineering. To take a single instance, how many are the forms and functions of the class of machines known as the dynamo! Series dynamos, shunt-dynamos, compounded, over-compounded, under-compounded, separately excited, alternating, two-phase, and many other types of dynamos exist. And a large fund must be voted from the exchequer if each and every one is to be separately represented in the students' laboratory, together with all the principal types of other things.

But the principle of *multum in parvo* often solves the difficulty, and places at the Professor's disposal a single machine which is warranted to do everything that all other machines put together can do. Some such machine we find in the Universal Dynamo, manufactured by Messrs. E. H. Cadiot and Co., of Paris, which, by an ingenious arrangement of plug switches and binding posts, can be variously modified so as to become any one of the different kinds of dynamos we have named. The general form of the machine is shown in Fig. 1 ; and in Fig. 2 is represented the usual arrangement of driving gear by means of which it may be worked by 2-student-power, while the other students are making the tests. In another form the support is mounted on small wheels and provided with handles, like a lawn mower, so that it can readily be trundled about.

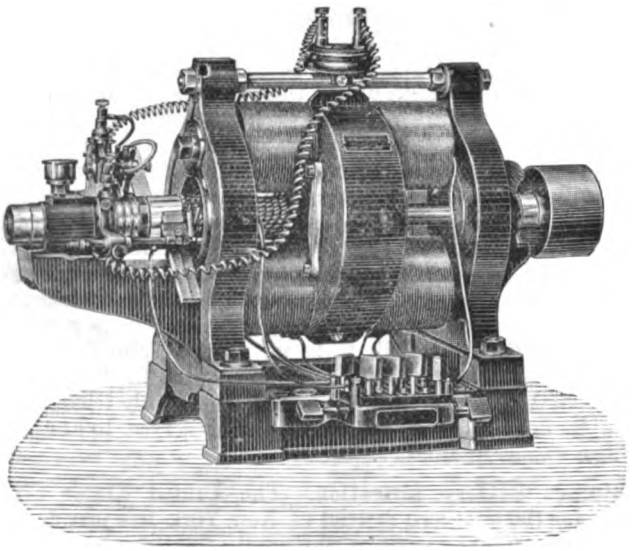

FIG. 1.

A "practical man" may have his objections to a dynamo which by means of a plug or two can be transformed from an alternator into a compound dynamo for constant voltage ; but in a student's dynamo these objections do not count. Efficiency is no object—

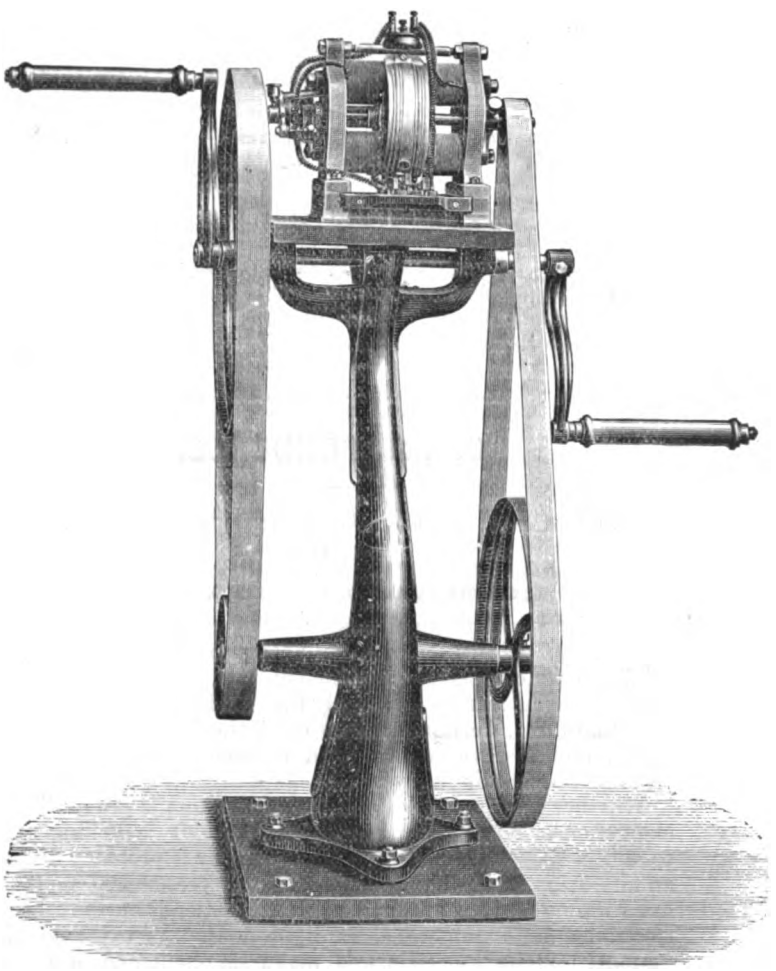

FIG. 2.

unless to the man who is grinding away at the handles. Indeed, a bad dynamo is often the most instructive one, and inefficiency often brings out useful truths almost in proportion as it wastes useful energy.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 22, 1893.

Incandescent Lamp Litigation.—On July 20th the United States Court at Milwaukee, Wis., handed down a decision granting an injunction against the Oconto Lamp Company. The defence in this case, like in those at Boston and St. Louis, was what is known as the "Goebel defence." It will be remembered that the St. Louis court in the case of the Columbia Company considered this defence strong enough to justify it in refusing to grant a preliminary injunction in favour of the Edison lamp, while the Boston court decided the reverse. There is thus one decision sustaining the Goebel defence and two decisions against it. The impression seems to prevail that this is the last of one of the most remarkable defences ever presented before a court. There is a rumour that the next defence will be based upon a claim for priority for Swan as the inventor of the incandescent lamp. It is stated that this case has never been thoroughly tried, having gone by default in one case abroad and served to annul the Edison patent in another.

Storage Battery Litigation.—The United States Circuit Court for the southern district of New York has just declared the famous Faure patent on the application of active material in the form of paste, paint or cement, to have lapsed and expired by reason of the prior expiration of the Faure Spanish patent for the same invention. This seems to leave the field clear for the licences of the Brush Company, whose fundamental patent on the use of a metallic support for the active material has been sustained by the courts. The long litigation in the United States on various storage battery patents has had a very depressing effect on that industry, and the outlook for the future seems none too bright on account of the restriction in regard to the use of a metallic support.

The International Electrical Congress.—It is probable that the subject of a millimetre wire gauge may come before the Chicago Congress, and a determined effort will be made to have the Congress express an opinion in regard to the definition of the candle-power of arc lamps in terms of watts; it is not thought that the Congress can take any formal action on this latter question, but it is hoped to have it favoured by at least informal action, which will, it is thought, be sufficient to influence the electrical public.

CORRESPONDENCE.

VELOCITY OF GRAVITY AND A RESISTING MEDIUM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: To avoid misapprehension, will you allow me to explain that when I pointed out that an aberrational effect of gravity might partly compensate for the effect of a resisting medium, I by no means intended to imply that I believed in these things as actualities. Certainly if they exist they must be extremely small, and I have several good reasons for believing that etherial viscosity is really *nil*.

Whether it be so or not, and whether there is gravitational aberration or not, I never contemplated gravity travelling with so slow a speed as that of light. Gravity is probably due to an alteration of the ether caused by the presence of matter; but I see no reason for supposing that it depends on the ether's electromagnetic properties, as light does. As expressed in "Modern Views," electric and magnetic phenomena are concerned with a shearing of the ether, a displacement or motion of its constituent parts in opposite directions; whereas gravity is probably due to an effect taking place in the ether as a whole.

If the ether is really incompressible, as it appears to be, then gravity need not *travel* at all, but simply *exists* throughout space round every material lump. This is what I think most likely.

It may be interesting to note that if gravity is caused by a stress analogous to a Maxwell stress, the etherial tension near the earth is 600,000 atmospheres, and near the sun 10,000 times as great; but that the stress produced by the sun over here is less than three atmospheres. Good steel can only stand 10,000 atmospheres' tension, or one-sixtieth of the terrestrial gravitational stress. The ether is no inferior sort of material. It would appear to be not only infinite in size but in other properties also.

At the same time the etherial stress caused by an ordinary lump of matter is excessively minute; it would need a globe of water 100 yards in diameter, for instance, to cause a stress of 1 dyne per square centimetre, or one-millionth of an atmosphere; and the stress caused by a vortex atom (always on the Maxwell-stress-hypothesis of gravity) is 10^{-23} of a dyne per square centimetre. This is all the residual effect which our hydro dynamic vorticians have to account for in order to explain gravity.—Yours, &c., OLIVER J. LODGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: After reading Dr. Lodge's interesting letter in *The Electrician* of July 28th, it seemed to me that it might not be out of place to record a few considerations suggested by the same. They are not objections to the theory given; but are intended to draw from him or from others some further discussion of the matter.

(1.) If the planet be "kept going" in spite of viscous friction, then work is being done upon it; and we must look for a disappearance of some other form of energy at an equivalent rate.

(2.) If I have not misunderstood the meaning of "lag," I imagine that it is assumed that, if there be such lag, the planet experiences at any moment a force which is the same in magnitude and direction as that which, if there were no lag, it would have experienced at some previous moment. Some suggestion as to the physical explanation of this would be instructive.

(3.) If the above view as to the meaning of "lag" be correct, then in the case of a body approaching the sun the gravitational stress between them would be at each moment *less* than if the two bodies had been at rest; and, if moving away from the sun, it would be *greater*. A lag in gravitation would then act *with* viscosity as regards perturbations of comets moving in hyperbolic paths, over the greater part of their paths.

(4.) And, perhaps, similar reasoning would, in the case of elliptic orbits, account for the changes in the ellipse, which are of such importance in what may be called the "Theory of Ice Ages."

It will be seen that in (3) and (4) attention is drawn to the fact that there would be lag in magnitude as well as lag in direction of the gravitational pull.—Yours, &c.,

W. LARDEN.

THE PARSONS STEAM TURBINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your comments on Prof. Kennedy's recent trials of the Parsons steam turbine (July 21st, p. 303), the reference to my own earlier trials contains an error that is worth correcting. Speaking of the tests made by me last August, in which superheated steam was used, you give 27.6 lb. as the recorded consumption of feed-water per electrical horse-power hour, whereas in fact it was 27·7lb. per *Board of Trade electrical unit*, or kilowatt hour. Prof. Kennedy's trials make the consumption slightly less than this, but the main improvement which they record is the augmented output from a machine of the same size. In this respect it appears that Mr. Parsons has bettered even his remarkable achievement of a year ago by something like 50 per cent.; and Prof. Kennedy's figures show, by comparison with mine, that this great increase in power has been secured without loss—

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indeed, with some gain—in efficiency. That there may be no mistake I put the figures side by side:—

Tests of Parsons Steam Turbine and Dynamo.

—	Rate of output during the test.	Consumption of feed-water. Per E.H.P hour.	Per B.T.U.
	kilowatts.	lb.	lb.
Ewing: August, 1892.			
(1) Steam at pressure of 103lb. in boiler, superheated 58°F.....	102	21·2	28·4
(2) Steam at pressure of 101lb. in boiler, superheated 127°F.	78	20·7	27·7
Kennedy: May, 1893.			
Steam at pressure of 97lb. in boiler, superheated 55 F.....	123	20·3	27·2

It will be seen from this table that with the same moderate degree of superheating as Prof. Kennedy used, I found the consumption of feed-water to be 21·2lb. per electrical horse-power hour, while in his test, with the machine altered to give a larger output, the consumption of feed-water was reduced to 20·3lb. which is 4 per cent. less. Neither in Prof. Kennedy's tests nor in mine was any deduction made from the measured amount of feed-water on account of boiler leakage, although it was known that some leakage was taking place—a fact which, of course, emphasises these very striking results. As Prof. Kennedy justly says, they rank among the best hitherto obtained in the direct driving of dynamos by condensing machinery.—Yours, &c.,

J. A. Ewing.

Cambridge, July 29, 1893.

LEGAL INTELLIGENCE.

Addison and Others v. Ness.

On Thursday this case came before the House of Lords by way of appeal from a judgement of the Court of Appeal, reversing a judgment of Mr. Justice Kekewich.

The question depended on the construction of an agreement made between the promotors of the Oriental Telephone Company (Limited) and the Company itself, which was incorporated in 1881 with a nominal capital of £300,000 in shares of £1 each. The promoters were to receive a certain number of shares, fully paid up, as part satisfaction of the purchase money payable to them, called "Vendor's shares," the rest of the shares being Ordinary shares. It was part of the agreement that during the first five years of the Company's existence the holders of the Vendor's shares should not participate in the profits of the Company until the holders of the Ordinary shares should have been paid a dividend of 6 per cent. per annum. Then the holders of the Vendor's shares were to receive 6 per cent. on their shares, and the balance was to be applied in paying dividends on all the shares, *pari passu*, in proportion to the amount paid up. Any deficiency in the dividends on the Ordinary shares was to be made up out of the profits of the Company in future years, in priority to the rights of the Vendors to participate in them. At the end of the first five years there was a deficiency amounting to £20,000, and the question was, how the dividends of the Company were to be dealt with after the period of five years. The holders of the Ordinary shares contended that they were then entitled to receive their rateable dividend out of the profits, and to have the balance of those profits applied to the making up of the deficiency on their dividends during the first five years in priority to the rights of the holders of the Vendors' shares to participate in profits; while the holders of the Vendors' shares held, on the other hand, that until the deficiency was made up the holders of the Ordinary shares were no more entitled to dividends than they were, and that the whole of the profits applicable to the payment of dividends must be applied preferentially in or towards making up the deficiency.

Mr. Justice Kekewich decided in favour of the contention of the appellants, who represented the Ordinary shareholders; but his decision was reversed by the Court of Appeal.

Lords Halsbury, Watson, and Macnaghton were of opinion that the judgment of the Court of Appeal should be reversed, and the judgment of Mr. Justice Kekewich restored, Lords Morris and Shand dissenting.

The judgment of the Court of Appeal was reversed, and the respondent ordered to pay the costs.

Consolidated Telephone Construction and Maintenance Company (Limited).

Application was made on Saturday to Mr. Justice Stirling by Mr. Buckley, Q.C., for power to reduce the capital of this Company. He stated that in consequence of the taking over of the Telephone Company of Austria, in which this Company held shares, by the Austrian Government, a sum of about £50,000 had been set free, and part of this sum of was proposed to utilise by paying off the Preference shares of £1 each, which would absorb £22,400. Then, on account of the running out its several of the patents under which the Company worked, there had been a depreciation in the assets of the Company which the Directors estimated to be not less than £24,000, and they desired to write off 2s. per share on the Ordinary shares on account of loss.

His LORDSHIP made the necessary order, remarking that it was merely a return of capital in excess of the requirements of the Company.

Hutchinson v. Gill.

This action, which came before the West Riding Summer Assizes last week, was brought by Mr. W. B. Hutchinson, electrical engineer of Liversedge, to recover damages for slander against Mr. J. Gill, a member of the Heckmondwike Local Board. The alleged slander was uttered in connection with the appointment of an electrical engineer by the Local Board, and in the result a verdict for the plaintiff with costs, according to agreement, was assented to by both parties, and the jury found accordingly.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

Tenders Invited.—The Cheshunt Local Board invite tenders for the public lighting of their district by gas, oil, or otherwise. Specifications may be seen at the Surveyor's office, and tenders must be in by Monday next.

——— The Technical Instruction Committee of the York Town Council invite tenders for the wiring of the Institute in Clifford-street for the electric light. Specifications, forms of tender, &c., can be obtained from Mr. A. Creer, the city engineer, to whom tenders must be delivered by noon on Tuesday, August 15th. Further particulars appear in our advertisement columns.

——— The Committee of the Derby Public Library Museum and Art Gallery invite tenders for the wiring of their buildings, and for the supply of fittings and accessories. Tenders must be in by the 9th instant.

——— The Gateshead Industrial Co-operative Society (Limited) propose to instal the electric light in their Jackson-street premises, tenders for which must be in by Saturday, the 12th instant.

Tenders Accepted.—The Yorkshire House-to-House Electricity Company (Limited) have accepted the tenders of Messrs. W. Nicholson and Co., of Hunslet, Leeds, for the builders' work, and of Messrs. John Fowler and Co., Leeds (Limited), for the engines, dynamos, &c., for the extension of their works at Leeds.

——— The Gas and Lighting Committee of the Bolton Corporation have accepted the tender of Messrs. Hick, Hargreaves, and Co. for the supply of the steam boilers for the central electric light station, but have deferred the acceptance of tenders for engines and for the erection of the building.

——— The Hampstead Vestry on Thursday last week had under consideration the report of the Electric Light Committee upon the tenders received for erecting buildings for the central electric light station, and for the supply of the plant. The Committee recommended the acceptance of the tender of Messrs. R. A. Yerbury and Sons, of Kilburn, for the erection of the chimney shaft and buildings at £7,350, and that of Messrs. Siemens. Bros. and Co. (Limited) for the plant, mains, &c., at £19,794; and the Vestry adopted both recommendations after some discussion. Thirty-one tenders were received for the supply of portions of the plant, and the following were from firms wishing to supply the whole of the machinery, &c.:—

Brush Electrical Engineering Company (Limited)	£22,047
Messrs. Latimer Clark, Muirhead and Co. (Limited)	21,850
" " " (alternative tender)	21,129
Messrs. Sharp and Kent	21,572
Messrs. Crompton and Co. (Limited)	21,512
Electric Construction Company (Limited)	21,232
Messrs. Siemens Bros. and Co. (Limited)	19,914
" " " (alternative tender)	19,120

Messrs. Siemens Brothers and Co.'s tender of £19,914 was accepted, as stated above, subject to a deduction of £120.

——— The Lighting and Electrical Committee of the Cardiff Corporation have decided to recommend the Council to accept the tender of Messrs. Siemens Bros. and Co. (Limited) for the supply of arc lamps, and that of Messrs. W. C. Hampton and Co. for the supply of cast-iron pipes for the underground cables.

Sales by Auction.—Messrs. Wheatley Kirk, Price and Goulty announce important sales of electrical stock, stores, dynamos, instruments, and engineering plant and machinery *in re* Blakey, Emmott and Co., Limited (in liquidation). The sale will take place at an early date, and includes the entire stock and contents of the works at Halifax. Catalogues will shortly be ready, and all further particulars can be obtained from the auctioneers, 49, Queen Victoria-street, E.C., and Albert-square, Manchester.

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APPOINTMENTS VACANT.—The Hove Commissioners advertise for an electrical engineering assistant, competent to supervise the construction of culverts, the laying of electric light mains, and the erection of electrical plant and generating machinery for the lighting supply of Hove (Sussex). Applications must be sent in to the Town Clerk, the Town Hall, Hove, not later than the 9th inst. Some further particulars are given in our advertisement columns.

——— The Government of India requires a mechanical engineer to take charge of the telegraph department workshops at Calcutta. The appointment is on a five year's agreement, and the salary is Rs.850 per mensem, rising by increments to Rs.1,000 per mensem. Further particulars appear in our advertisement columns, and applications must reach the Secretary, Public Works Department, India Office, S.W., not later than 31st inst.

MESSRS. PATERSON AND COOPER.—We are informed that Mr. W. C. Martin has ceased his connection with Messrs. Paterson and Cooper as manager of their Glasgow branch ; and that Mr. E. Geo. Tidd has been appointed in his place.

MESSRS. W. T. GOOLDEN AND CO.—This firm announce that their works and offices will be closed for the annual holidays from August 28th to September 2nd, inclusive.

STEAM SAVING APPLIANCES. — The Chadderton Iron Works Company send us their new catalogue of M'Dougal's patent steam saving appliances, several of which are illustrated and described in the pamphlet. The Company's specialities include patent steam traps for any variation of pressure, combined steam dryers and water and dirt separators, anti-primers, mechanical stokers, sight feed lubricators, &c.

MESSRS. JULIUS SAX AND CO.—The Court of Common Council have resolved to grant this firm the building lease of land in Charterhouse-street on which to erect a lighting station for the markets, at £500 per annum, the Court to pay £6,000 in the event of their requiring the land before the expiry of the lease, for any buildings thereon.

FOWLER-WARING CABLES COMPANY (LIMITED).—A very attractive and interesting illustrated and descriptive catalogue has just been issued by this firm. The work comprises a number of coloured illustrations of cables for electric lighting, telephonic and telegraphic purposes, and of junction boxes, fittings, tools, &c. In the lead-covered cables, for which the Company enjoy a well-earned reputation, the difficulties first experienced have, in a great measure, been overcome, and this type of cable is now being extensively adopted. In the section of the catalogue which deals with concentric wiring we find fully illustrated descriptions of junctions, switch-boxes, &c., specially adapted to the lead-covered and "dry-core" cables manufactured by the firm. A brief description is given of the methods and materials employed in the manufacture of the Fowler-Waring cables, written by Mr. A. E. Mavor, the General Manager. Testimonials are included from Lord Kelvin, Sir Frederick Bramwell, Mr. Preece, and others. A variety of useful tables, instructions for laying and jointing, and a telegraph code for ordering, add to the value of the publication. In this era of well-arranged and carefully-compiled catalogues the book under notice certainly takes front rank.

MESSRS. C. A. PARSONS AND CO.—The new catalogue and price list of this firm contains, in its introduction, much useful information. The cost of construction and maintenance of the Cambridge and the Newcastle central stations are discussed ; and several large illustrations of these stations, and of details of the plant, are given. The catalogue gives price lists of the Parsons steam turbines, dynamos and alternators, and of sundry auxiliary details, and includes useful tables of the dimensions and performances of the Parsons engines.

"FIBERITE."—We have received from Messrs. Shippey Bros. some specimens of "fiberite," which is stated to be "a new compound material for incandescent lamp filaments," and which can be pressed into sheets or drawn into very fine threads as required.

BANDON.—A public meeting of the ratepayers was held on Monday when a resolution was adopted, calling on the Town Commissioners not to give their consent to the proposed application by the Bandon Electric Lighting Company (Limited) for a Provisional Order.

BANK HOLIDAY ARRANGEMENTS.—The Post Office authorities issue a special circular relating to the arrangements for postings, parcel posts, and express delivery for Monday, August 7th, which can be obtained of any district, or sub-office.

CLEATOR MOOR.—The Co-operative Society have instructed Mr. Watson Bell, of Whitehaven, to instal the electric light in their mill and warehouse. The plant to be supplied will be capable of supplying current for lighting the central stores, if this should be deemed advisable.

COVENTRY.—At the meeting of the Town Council on Tuesday, the Electric Light Committee recommended that they be empowered to employ a consulting engineer, but it was decided that before this was done the Committee should present a report of their investigations, so far as they had proceeded.

DOWNPATRICK.—At a special meeting of the Town Commissioners, on Friday, to consider the lighting of the extended town boundary, it was resolved that unless arrangements could be come to with the gas company some other means of lighting should be adopted.

EDINBURGH.—At the meeting on Monday of the Edinburgh and Leith Corporation's Gas Commissioners, a letter was read from the Town Clerk of Edinburgh asking if the Commissioners would be willing to supply the Corporation with gas for their engines to be used in the production of the electric light at the same rate as they did at present for public lighting. The letter pointed out that the price at which the gas would be supplied would be an important factor in arriving at a decision whether gas or steam engines would be used. In the discussion which followed, objection was raised to the gas being supplied at a lower rate than was charged for private lighting, as it was argued that the City would be supplying the electric light to the Commissioner's best customers, and the latter would, therefore, be simply cutting their own throats by supplying gas so cheaply for producing the electric light. The matter was ultimately remitted to the Works Committee for consideration, and the Gas Commission will hold a special meeting on the 14th inst. to settle the question.

FLEETWOOD.—The Special Committee of the Local Board who are considering the question of the electric light are visiting various central stations in order to obtain information.

HASWELL (DURHAM).—It has been decided to light the premises of the Haswell Co-operative Society by electricity.

GLASGOW.—The applications for the supply of the electric light are so numerous that it is evident the present plant will soon become inadequate to meet the demand, and the Town Council have remitted to a sub-committee the consideration of a scheme for the extension of the system. It is proposed to remove the dynamos which generate the supply for street lighting from Waterloo-street to the premises in John-street, formerly occupied by Messrs. Mavor and Coulson, and to erect in their place plant for the supply of current for house incandescent lighting.

GREAT GRIMSBY.—At a meeting of the Public Lighting Committee of the Town Council, held last week, the surveyor gave particulars of some replies he had received from other local authorities with reference to street electric lighting. The consideration of the matter was postponed for a month.

HIGH WYCOMBE.—The Town Council at their last meeting decided to take the necessary steps towards obtaining a Provisional Order for the lighting of the town by electricity.

LANCASTER.—The Local Government Board have sanctioned the borrowing by the Corporation of £25,000 for the purpose of electric lighting, respecting which an inquiry was recently held. The Town Council at their last meeting accepted various tenders for the building work in connection with the erection of the central station, and they have fixed the price for the current at 7d. per Board of Trade unit.

LECTURE.—On Friday evening last, Mr. George Offor delivered a lecture on "Electricity as applied to Domestic Purposes," before a large audience at Westwood House, Upper Sydenham, S.E. The lecturer dealt with the importance of the undertaking carried out by the Crystal Palace and District Electric Supply Company, and generally with the subject of the uses of electricity for domestic purposes. Taking the Crystal Palace as a centre, the important residential neighbourhood surrounding it had been included in the Company's area of supply, which extended about two miles from north to south, and 1½ miles from east to west. Between 7 and 8 miles of trenches had been constructed, in which more than 50 miles of cables had been laid, and pilot wires for regulating the pressure, which is delivered at 100 volts. At each sub-station there was a motor dynamo and battery of E.P.S. accumulators of the K type. The lecture was illustrated by a successful exhibition of cooking, ironing, ventilating, cigar-lighting, &c. Mr. Offor concluded by showing the rapid progress of the electric supply industry, and referred to the dividends paid by a large number of metropolitan and provincial companies, as indications of its future success. The first house in the Company's area was connected with the mains in February last, and there were now about 3,000 actually running or being wired.

MANCHESTER.—The Manchester Chamber of Commerce have had under discussion the increasing number of subway constructions for electric and other purposes under the streets of the city, and have resolved that it is essential to the public interest that the Corporation should continue to retain complete control over the public streets, and over communications of all kinds beneath the surface.

PETERBOROUGH.—Prominent tradesmen of this city are pushing forward the electric light. Mr. R. Hammond recently addressed a meeting of the townspeople on the subject and secured an appreciative audience. The Mayor (who presided) said the Corporation had received no request from the townspeople for the electric light.

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was ultimately decided to memorialise the Town Council to her adopt the electric light or to allow a private company to so.—With reference to the above, the Town Council at their t meeting decided to oppose the application of the Midland ouse-to-House Electricity Company (Limited) for a Provisional der for supplying electricity within the borough, and directed eir engineer to report upon the matter with a view to the rporation themselves erecting a central station.

RUGBY.—The Local Board on Saturday agreed to a request from Rugby School Electric Lighting Company (Limited) that the ard should undertake the task of laying the cast-iron pipes for cables where they crossed the public road, subject to their ng relieved from all subsequent liability.

SHOREDITCH.—The Electric Lighting Committee of the Vestry, he last meeting, reported that they had considered the question the joint purchase of the Pitfield-street site for the purposes of cting an electric light station, free library buildings, and public hs, and recommended the purchase of the site by the Vestry. ong discussion ensued, and was eventually adjourned.

THE ELECTRIC LIGHT IN PRINTING OFFICES.—The offices of the rkshire Post, at Leeds, have been fitted with the electric light, installation consisting of upwards of 400 incandescent lamps l four arc lamps. In the type-composing department, in which re are 200 lights, a specially designed swivel bracket has been roduced, which allows the lamp to be moved over a considerable ce, and is extremely effective for its purpose.

TWICKENHAM.—The Local Board had before them at their last eting a report by the surveyor on the schemes submitted by ssrs. Hammond and Co. for the electric lighting of the district. e annual cost for lighting the areas suggested was estimated at ,840, and (for a much larger area) £5,591. The present cost of street lighting by gas in these areas was £150 and £580 respec-ely, and it followed that some £2,700 or £5,000 would have to be ceived from private lighting to make the scheme pay. After some cussion a decision on the subject was postponed until the Lighting mmittee had ascertained by inquiry whether there was any proba-ity of the requisite number of private consumers taking the current.

WANDSWORTH.—At the last vestry meeting, in reply to a ques-on as to the possibility of the electric light being supplied to strict, Dr. Howell thought it would be a good many years before ectricity would come to Wandsworth. The fact was that all the mpanies that proposed to supply Putney and Wandsworth with ectricity had failed to get the capital to float themselves, and so e matter had fallen through.

WHITEHAVEN.—The Harbour Committee have decided to recom-end the Local Board to light the Harbour by electricity at the tal cost of £220 per annum, on the terms proposed by the Elec-ic Lighting Committee.

WORCESTER.—The Board of Guardians at their meeting on Thurs-ay week had under consideration the question of lighting the new orkhouse by electricity; but after some discussion it was decided postpone the matter.

COMPANIES' MEETINGS AND REPORTS.

The Direct United States Cable Company (Limited).

The thirty-second ordinary general meeting of this Company was held Winchester House, Old Broad-street, on Friday, July 28th, under the residency of Sir John Pender, G.C.M.G., M.P.

The SECRETARY (Mr. T. Finnis), read the notice convening the meet-ng and the minutes of the last ordinary general meeting, which were pproved by the present meeting and signed by the Chairman as correct. he report of the Directors, which has been published in *The Electrician*, as taken as read.

The CHAIRMAN: Before I move the first resolution I will, as usual, o over the report and give you any further information which I onsider it desirable that you should have. In fact, we give you, as a ule, all the information that we ourselves possess, and we always think hat the more information we can give to our shareholders on an ccasion of this kind, the more it increases that confidence which ought o exist between this side of the table and the other side. The revenue or the half-year to June 30th last, after deducting outpayments, amounted n round figures to £40,837, and the working and other expenses, ncluding income-tax and depreciation, to £18,898, leaving a balance of £21,939, as the net profit of the half-year, making with £3,129 brought orward from the previous year a total of £25,068, which has been appropriated as follows:—Interim dividend of 3s. 6d. per share for the quarter to March 31st £10,624. 5s.; proposed final dividend of 3s. 6d. per share for the quarter to June 30th £10,624. 5s.; transferred to reserve fund £3,000; balance proposed to be carried forward £819. 2s. 4d. The revenue as compared with that in the corresponding period of last year shows an increase of £1,822. This is not a large amount but it is on the right side of the account, and considering the very general depression which has existed, the result must be regarded as satisfactory. The expenses in London, as shown by abstract "A" in the accounts, remain so very nearly the same as in the corresponding period that a comparison of the items is unnecessary. The total shows the small increase of £24. The expenses at stations, as detailed in abstract "B," shows as follows:—Increases of £260 in salaries and wages, £27 in maintenance, £26 in petties, £13 in rent, fuel, and light, £67 in travelling, £50 in printing, and £100 in agencies. At the same time several of the items are slightly reduced. On the whole these expenses show an increase of £490, chiefly due to the new head station at Mark-lane, which was not working in the corresponding period of the previous year, though I referred to it. In the remaining items of expenditure there are reductions of £131 in Directors' remuneration, £69 in law charges, and £476 in freight of cable account, the total of the expenditure in the aggregate showing a saving of £121—not a large sum, but again on the right side of the books. A comparison of the past full year's working to June 30th with that in the corresponding period shows that while our revenue has been more than maintained, our working expenditure, notwithstanding the running of additional stations and new agencies, has only been very slightly increased. The reserve fund, increased by the interest on the investments, £4,117 6s. 6d., and £3,000 transferred from the revenue account, now amounts to £267,415 12s. 7d. The investments, which are entered at "cost" in the balance-sheet, remain unaltered since the last general meeting, and stand at a total of £234,152. 13s. 7d. Gentlemen, these are the hard facts connected with the working of the system during the last six months, and it now devolves upon me to submit a resolution approving of the accounts. Before doing so, however, I will make a few remarks, as usual. I may say that I have probably never stood before a meeting of this Company when America was occupying such a peculiar position as it does at the present moment. The unsatisfactory state of the financial system in America, I daresay you are aware, is more or less due to the silver question. There are, however, other questions which have had more or less a part in producing the apparent collapse of confidence which we witness for the moment; but we have seen—although not so bad as at the present—very great depression from time to time. We have, however, also seen that a cycle of bad times has generally been followed by a cycle of good times, and I have no doubt that that will be the case on this occasion. There is great energy in America, which also possesses immense resources, and I have no doubt that these will come to the front as soon as the lowest depth at which the present depression is going is reached. Since I had the pleasure of addressing you last I have paid a visit to our important station at Ballinskelligs, where we have been making some rather considerable alterations and improvements, and, I may say, additions. As you are aware, when this Company was first formed, our establishment there was more or less composed of wooden dwellings, which we have to a considerable extent replaced by good strong concrete buildings. You can well understand that after 18 or 20 years wooden houses are not very much to be relied upon, and they are barely strong enough to stand the force of the wind, and certainly they would not bear any exceptionally severe strain. I was very pleased during my visit to see that everything there looked cheery, prosperous, and upon the whole satisfactory, and I came to the conclusion that as soon as we got rid of the old wooden houses, and replaced them with concrete buildings, making the position more secure, our property would be made more valuable, and the position of our people who conduct the work at that important station would be rendered more comfortable. The past half-year has been a favourable one so far as repairs are concerned. As you are aware, when our cables break a great deal of money is almost invariably expended in effecting the repairs. During the past half-year we have been exempt from that. While we have not been able to increase our dividend, we have been able, to some extent, to add to our reserve fund, which is to enable us, in the event of accidents and interruptions in our cables, to repair them. I need not, on this occasion, go more closely into the details of the working of our business. I find that the last time I had the pleasure of addressing you I went very fully into the whole position and gave you a large amount of information, as I daresay many of you who were present will remember. All I need say now is this—that we are not in a worse position to-day than we were in the last time we met. I think that, having stood the effects of the great depression that has been existing in trade generally, and seeing that we have not only maintained our position but rather improved it, we are probably in a better position to-day than we were in when I last had the pleasure of addressing you. I hope that when I see you again six months hence I shall be able to speak to you more cheerfully than I have done to-day; we are, however, passing through this trouble; but when you look abroad, and see how other people are suffering, I think you will admit that we have very little to complain of, and with a return of better trade in America, we shall naturally participate in the increased prosperity which will result. I now beg to propose the following resolution:—

"That the report of the Directors dated July 14, 1893, together with the statement of accounts to June 30, 1893, annexed thereto, be and the same are hereby received and adopted, and that a final dividend be now declared of 3s. 6d. per share, free of income-tax, making, with the interim dividends already paid, a total dividend of 3½ per cent. for the year ended June 30, 1893."

Mr. E. M. UNDERDOWN, Q.C.: I beg to second that.

The CHAIRMAN: If any gentleman has any question to put to me I shall be glad to answer it to the best of my ability.

Mr. W. GOODSALL: You have not made any statement as to the working condition of the cables. I presume that they are working well?

The CHAIRMAN: If there had been any hitch or anything of that kind you may depend upon it that I should have mentioned it to the meeting. I, however, just made the remark that during the last 6 months we have been free from any faults, and consequently we are in a satisfactory position.

The motion was carried unanimously.

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The CHAIRMAN: The next resolution is

"That Charles Meara, Esq., be and he is hereby re-elected a Director of this Company."

Admiral of the Fleet the Hon. Sir HENRY KEPPEL, G.C.B., D.C.L., seconded the motion.

The CHAIRMAN remarked that Mr. Meara was not present. He resided in Antwerp, which was rather an important source of their revenue. Their colleague, however, visited them occasionally, and his absence on the present occasion was attributable to the fact that he was not quite well.

The resolution was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. JAMES PENDER, the following resolution was afterwards passed unanimously:—

That E. M. Underdown, Esq., Q.C., be, and he is hereby re-elected a Director of this Company."

The Rev. J. HUGILL then proposed the re-election of the auditors, Mr. John G. Griffiths, F.C.A., and Mr. John Sawyer, F.C.A.

The motion was seconded by Mr. A. DYET.

The CHAIRMAN: I will only say with respect to our auditors that they are appointed every year. They are chartered accountants, who take special charge of our accounts, bringing them before you according to the form which they consider desirable. They are not dictated to or even advised in any way. They make out this statement, and we accept it, as a matter of course. They represent the body of the shareholders, and as far as my observation goes, I believe they represent them very efficiently. He then put the motion, which he declared carried unanimously, adding that that concluded the business of the meeting.

Mr. JOHN NEWTON then proposed a vote of thanks to the Chairman and the Directors for their services in the past half-year. It was not an easy task to steer clear where there was so much competition, and he thought that the Directors had succeeded very well.

A SHAREHOLDER seconded the motion, which was unanimously agreed to.

The CHAIRMAN: On behalf of my colleagues and myself I beg to thank you. I can only assure you that the more we feel that we have the confidence of the shareholders, the more we are satisfied to go on with our work. A little encouragement even to old as well as to young makes life go on more smoothly and pleasantly. I should be extremely sorry if it ever came to the position that our interests were not mutual. They are, however, entirely and completely mutual. The more we can make things go pleasantly and better for you, the more satisfactory is it to us. I thank you, gentlemen, on behalf of my colleagues and myself.

The proceedings then terminated.

Anglo-American Telegraph Company (Limited).

The ordinary general half-yearly meeting of the proprietors of this Company was held at Winchester House, Old Broad-street, on the 28th ult., the Most Hon. the Marquis of Tweeddale, the Chairman, presiding.

The SECRETARY (Mr. T. H. Wells) read the notice convening the meeting, and the minutes of the previous meeting, which were confirmed and signed.

The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said: Gentlemen, I now invite your approval of the report and accounts which have been in your hands for some days. You will observe that the receipts amounted to £146,885, being an increase of £367 over those of the corresponding period of 1892. The actual increase is somewhat larger for this reason, that in the half-year 1892, there was included an item of something like £1,600, which was really a balance which remained unadjusted for some years. Therefore, the actual difference is something like £2,000 in favour of this half year, as compared with the corresponding one. It is remarkable how little the accounts for the last four half-years have altered. In 1890 the receipts were £144,915; in 1891, I am talking of the half-year to the end of June, they amounted to £136,483, a substantial falling off, due to the interruption of communication with the west coast of South America; in 1892 the receipts reached the figures £145,000, and this half-year, as I have mentioned, they amounted to £146,885. This half-year, in reality, is the best that we have had for some time. I hope that the increase which we have enjoyed for the last six months will be not only maintained but improved. The traffic at the beginning of this month was very unsatisfactory, but during the latter part of it the returns have placed our income a little above what it was at the corresponding period of last year. The working expenses show an increase of £818, mainly due, firstly, to the loss caused by fire at St. Johns, mentioned at the last meeting, amounting to £343, and secondly to the increase of the salaries of our staff. This revision of the salaries of the staff had been promised for some years, and the matter has been taken in hand during the last six months. The average increase amounts to only £12. 15s. to each official, and the highest increment granted was £50. I do not think that any shareholder will grudge these increases. They are well deserved by long and faithful services. You will have, I daresay, observed that your Directors have agreed to subscribe £100 to the Victoria Fund. The navy has always shown a friendly disposition to the repairing ships of the various submarine cable companies throughout the world, and we thought that it was a good opportunity to show our gratitude for the assistance which various vessels of the fleet have been able from time to time to give us. The net result is that we are able to pay a dividend of 12s. 6d. per share on the Ordinary stock—not a very large one, I admit, but at the same time it is a dividend paid on stock which was very heavily "watered"—that is to the extent of 50 per cent. The proprietors have, no doubt, noticed with considerable satisfaction that the reserve fund stands at £1,007,261, or £7,000 over and above the amount which it was contemplated we should bring it up to. Whether this sum, or any other addition to it, during the current year may be made available for dividend must depend on our immunity from further interruptions and upon the speed with which the present interruptions are repaired. I am sure that you have seen with as much disappointment as your Directors that no less than two of our cables have broken down. The Brest—St. Pierre has always been a disappointing cable, and I have been looking at the number of times that it has been interrupted since we became possessed of it in 1873, as well as what it has cost us. I find that it was interrupted two or three years after we came into possession of it, and I think I am right in saying that it has been broken fourteen times since then. This has cost us something like £240,000. This is a very serious matter, and almost justifies the remark made by one of the shareholders at the last meeting, at which I had the honour to preside, doubting the propriety of repairing it any more. I do not think that we have come to that point yet, but still it is very annoying to find we have to undergo such an expenditure—something like £12,000 a year on the average, I may say—for a cable which does not yield a very large profit, which makes it all the more unsatisfactory. I may add that our ship "Minia" will proceed in a very few days to repair the two remaining faults. She has already repaired one during the half-year to which I am referring, and I can only hope that the other will speedily be accomplished. The record of the 1874 cable is a far better one. It appears to have been interrupted on two occasions, besides the present, and put us to no great expense in repairing it. The present interruption is the more serious because it is in deep water, and a great many miles from the other side of the Atlantic. The ship "Calabria," belonging to the Telegraph Construction and Maintenance Company, has been chartered for its repair. Even if these cables are repaired with the utmost possible speed and at the lowest possible expenditure of cable, the cost will be considerable. If any lengthened time is necessary and if a great many miles of cable are required to effect the repairs, I am afraid that I can hold out little or no hope of any portion of the reserve fund being made applicable to dividend. With regard to the old story of the law suit in France, I have very little to add to what appears in the report. I remember telling you at the last meeting that the delay in its settlement was very great, owing to the fact that our counsel was employed in the Panama case. Now the delay is owing to the French directorate of the Paris Company. A new Board, however, was elected a short time ago, and after the vacation we have every reason to hope and believe that the case will be proceeded with. The business of the Company has been conducted as usual with the same celerity, and I am glad to say with even increased accuracy, which is entirely due to the exertions and zeal of our *employés*, who deserve the greatest credit for the manner in which the business of the Company is conducted. I cannot conclude the few remarks I have to make without referring to the sad event which is mentioned in the report, namely, the death of Sir James Anderson. I do not propose to dwell on the valuable services, or I should say the invaluable services which he rendered to submarine telegraphy in its earliest days. These are familiar to you I have no doubt, and are indeed matters of history. Sir James was one of our Directors for twenty years. He was a man of excellent judgment, he had a very intimate acquaintance with everything connected with telegraph matters, he was most attentive to the business of the Company, and I know of no Director who had more implicitly the trust of the shareholders. I am sure you will all agree with me in a sincere expression of regret at his decease. I have also to add that our Managing Director, whose face you are all familiar with, has been for some time suffering from illness. The Board has this day granted to him three months' leave, and I hope that, at the end of that time, he will come back thoroughly restored in health. In the meantime his duties will be performed by our traffic manager, Mr. Carson, who has been in the Company's service for something like twenty years, having risen from the ranks, and he is most competent to carry on the duties of Mr. Weaver in that gentleman's absence. Gentlemen, I do not think that I have anything to add to these remarks, but I shall be glad to answer any questions that may be addressed to me. I now move—

"That the report of the Directors and the accompanying statement of accounts to June 30, 1893, submitted to this meeting be and the same are hereby received and adopted."

Mr. FRANCIS A. BEVAN seconded the motion.

Mr. BOURNE suggested that it was not advisable that any more repairs should be made to the Brest—St. Pierre cable, and further remarked that while the Chairman put its yearly cost down at £12,000, he found as a matter of fact that it averaged £30,000.

The CHAIRMAN said that it had cost about £240,000 during the last 20 years.

Mr. GOODSALL asked what was the depth of the 1874 cable.

Mr. NEWTON thought that if they had spent so much money in the repairs of that cable, surely it was reasonable to suppose that it was now becoming a good one. If they had had continuous repairs made to it, the breaks surely did not occur on the repaired parts. He thought that the matter ought to be left to the discretion of the Board. He joined in the expression of regret of the Chairman at the loss the Company had sustained by the death of Sir James Anderson, who, he said, was associated with the foundation of the Company, the work of which was one of the greatest achievements of history.

The CHAIRMAN, in reply to Mr. Daniel, said that by abandoning the Brest cable the Company would lose both in *prestige* and money, and believed, with Mr. Newton, that the last repair would add to its value. With regard to the French law-suit they must, he was afraid, take a very one-sided opinion, namely, that they ought to gain a great deal by it; but whether they would do so or not was a very different matter. They considered that they had been very badly used, and that they should

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receive substantial damages; but whether that would be so or not would be determined by the French courts. In reply to Mr. Goodsall, he might say that the depth at which the cable was laid was 2,000 fathoms. They had had a good deal of trouble in connection with their cables with the owners of property on the other side, but these difficulties had been disposed of, and those that remained unsettled would be overcome within a short period at no great cost to the Company.

Mr. BOURNE having proposed a hearty vote of thanks to the Chairman which the latter duly acknowledged, the proceedings ended.

Chili Telephone Company (Limited).

An ordinary general meeting of this Company was held at Winchester House, E.C., on Wednesday last, Colonel R. Raynsford Jackson in the chair.

The SECRETARY (Mr. Edmund Petley) read the notice calling the meeting, the report of the Directors and statement of accounts being taken as read.

The CHAIRMAN: Gentlemen, instead of dwelling particularly as it has been my custom hitherto to do upon the report of the year, I shall endeavour to place before you a retrospect of the operations of the Company since we took it over from the West Coast Telephone Company of Chili on May 1, 1889. We had at that time 2,070 subscribers; the gross revenue for the 11 months up to that date was $229,000, and the net revenue $90,000. The rate of exchange at the end of the year, which was the basis of the valuation of the liquid assets in Chili, was 24d., and the net profit of the Company was £5,520. Last year we had 4,219 subscribers, and the gross revenue was $449,000, and the net revenue in round figures was $185,000. You will see, therefore, that during that period the number of subscribers and the amount of net revenue have more than doubled, and yet the profit in London last year was only £5,359. I shall place before you the reason why such a large revenue in dollars has earned so small a revenue in sterling. The average rate of exchange last year, which was the basis of the valuation per dollar of the net profits, was 18d., as against 25¼d., per dollar. The rate of the exchange at which the liquid assets in Chili were valued was 15 as against 24d. Probably the case will be made clearer to you if I deal with the results. In 1890-1, the second and most prosperous year in our history the number of subscribers was 4,028; the gross revenue was $387,000 and the net revenue was $192,000. The proportion of the expenses to the gross revenue was 58½ per cent. I ask you to bear that figure in mind as I shall recur to it later. The profits in London for the year were £13,686, and the depreciation in the value of the liquid assets owing to the rate of exchange being "18d.," against 24d. in the previous year, led to a reduction of £3,089 in the profits. I shall not dwell on the working of the year 1891-92, which was the year of the civil war, but the net profits during that period were only $107,000 against $185,000 for the twelve months, 1892-93, yet the profits in London for the former year were in excess of those of the last year. That was due to the fact that the average rate of exchange in 1891-92 was 19½d., against 18d. last year, and the rate at which the liquid assets were taken was 19d., as against 15d. in the year under review. Now there is this remarkable fact to be noted, that, although the profit of dollars in Chili was only $7,000 less in 1892-93 than in 1890-91, when the profits in London were £13,689, the net profits in London in 1892-93 were only £5,395. I have entered into a calculation with the view of ascertaining what we should have been able to put before you this year if the rate of exchange had remained as it was in 1890-91. There would have been an increase in our net revenue of £4,617, and an increase in the value of the liquid assets of £3,025. These two figures, together with the profits actually shown in the accounts, would have been equal to £13,036, so that the fall in the rate of exchange is directly responsible for a diminution in the revenue for the year of £7,642, which will enable you to judge of the cause of the difficulties which we have had to contend with. The gross revenue for 1893 was over $60,000 more than it was in 1890-91, and the proportion of the gross earnings absorbed in working expenses was 59 as against 50½ per cent. in 1890-91. The rate of exchange has affected that expenditure also. The decline in the value of the paper dollar has increased the cost of everything sold and used in Chili, and the greater proportion of the gross revenue absorbed in working expenditure is due very largely to that. If, however, the proportion of the gross revenue absorbed by expenditure had been only 50½ instead of 59 per cent., it would have increased the profits of the Company by £3,780. In short, to the fall in exchange is attributable the unsatisfactory statement of the accounts which we have been obliged to place before you. It may be asked what, under the circumstances, do the Directors propose to do? The fall in the rate of exchange is not solely due to the fact that silver money prevails in Chili, and that we have a gold standard here, but it is attributable to the circumstance that there is a forced issue of paper money; and whereas you can estimate pretty nearly what the value of the silver dollar will be when you know the price of silver, there is no possibility of measuring the value of the paper dollar, the issue of which is not limited. The Chilians themselves have shown us how to deal with this matter. The Government itself has put up the tariff of its railways by 25 per cent., the gas companies have put up their charge by 50 per cent. Labour of all kinds is advanced by about 50 per cent. Rents have advanced 50 per cent. Therefore everybody having anything to sell or trade in in any way in Chili seeks to protect himself from the depreciation in the value of the paper money by securing as much as he can of that money, and your Directors have come to the conclusion that they must follow the example of the Chilians in that line of policy. We have put up the rates in some important centres in Chili, and are about to do the same in all of them; and we think that our position will be improved to a certain extent from that cause alone. I think that we have another source of hope. The President of Chili has announced the determination of the Government to do away as soon as possible with the forced issue of paper money. He has not simply announced that that is the intention of the Government, because on September 26th last year an Act of Congress was passed with the view of accomplishing that object. It was found not to be altogether the best Act that could be passed for the purpose, and it was modified, I believe, in March this year. But the President has not only declared that the forced currency will be stopped as quickly as possible, but he has indicated the source from which he hopes to derive the means of accomplishing the object of the Government. The Government is not approaching the subject in a light spirit. It seems to be dealing with it with forethought and resolution; and knowing, as we do, the determined and courageous character of the people who are in this matter supporting the Government, we may feel quite certain that they will give effect to that which they regard as being essential to the well-being of the country. The President has pointed out that after the fourteen years' experience which they have had, a forced currency and excessive fluctuations in the exchanges and the value of the paper money, are adverse to the trading interests and commerce of Chili, and that, therefore, it is necessary in the interests of the whole people that effect should be given to a sound financial policy. We have, therefore, reason to hope that with the advance in tariff which we feel it our bounden duty to the shareholders to make, and the sound financial policy foreshadowed by the Government, we may find that our enterprise will end in being eminently successful, and will justify the hopes originally held by the shareholders with regard to it. We feel that there may be some delay because the President has declared that it will take till 1896 to give complete effect to the policy of the Government, but it will be gradually working towards that end. But there is another ground upon which your Directors rely for thinking that it is possible in the current year that they may be able to set aside out of revenue sufficient to enable them to pay a dividend at the end of the year. We have practically closed, for the present at least, our capital account, and we are only spending money which is necessary to take up new subscribers, and, therefore, most of what we earn in Chili will be available for fulfilling the postponed hopes of our shareholders. I do not know that I can say anything more to elucidate the position of the Company. I do not like under circumstances such as these to indulge in prophecy. You will understand that what I have mentioned to-day is merely the belief of the Directors, and that there is a reasonable prospect of what I have indicated being realised. I beg to move:—

"That the report of the Directors with the statement of accounts now presented to this meeting be approved and adopted."

Mr. THOMAS GREENWOOD seconded the motion.

Mr. J. R. BAILLIE asked whether the rate of exchange was not now 14d.?

The CHAIRMAN said that it was 14¾d., but that it had been as low as 14d. The average rate for the year to which the accounts related was 18d. If they had been able to value their net revenue this year at 2s., as was the case in 1891, that alone would have increased their profits by £4,617, and if they had been able to value their liquid assets at the same rate, which was 18d. instead of 15d., they would have increased the profits by £3,225: and instead of showing £5,394 as the result of the year's working, they would have shown £13,036, so that the fall in the rate of exchange since 1890 had adversely affected the Company to the extent of £7,642. The Directors were not able to announce what the increase in the subscriptions would be, but they calculated that it would have a material effect on the receipts during the year.

Mr. BAILLIE further remarked that from what he saw of the property in Chili and its management, he ventured to say that their undertaking was in a very good condition indeed, as compared with other commercial enterprises there.

The CHAIRMAN said that he was glad to hear Mr. Baillie give expression to that belief, and in this connection he might point out that the results in Chili were very satisfactory, as there had been an increase in the gross earnings.

Dr. JOHNSON asked whether it was likely that there would be any opposition on the part of the Government or the municipal authorities to the Company raising its tariffs.

The CHAIRMAN replied that it was not likely that such opposition would come from the Government, with which they had very large contracts. At any rate, they did not now apprehend it.

The resolution was then carried unanimously.

The CHAIRMAN next proposed:

"That Mr. Thomas Greenwood be, and he is hereby, re-elected a Director of the Company."

He paid a warm tribute to Mr. Greenwood for his services to the Company.

Mr. E. QUILTER seconded the motion, which was agreed to *nem. con.*

Mr. GREENWOOD having expressed his acknowledgement,

The CHAIRMAN moved:—

"That the Hon. F. Ernest Allsopp be, and he is hereby, re-elected a Director of the Company,"

remarking that that gentleman's practical suggestions were often of great value to the Board.

Mr. COLE seconded the motion, which was carried unanimously.

Mr. BAILLIE proposed, and Mr. QUILTER seconded:—

"That Mr. Thomas A. Welton be, and he is hereby, re-elected auditor of the Company."

On the motion of Mr. COLE, seconded by Mr. BAILLIE, a cordial vote of thanks was accorded to the Chairman, Directors, and staff of the Company for their services during the year.

The CHAIRMAN, in returning thanks, observed that it was not when the profits were largest, and the general results of an undertaking were

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most satisfactory, that the Directors had the hardest work to perform; but he hoped that the time would soon come when the shareholders would pass such a vote even more cheerfully and with a feeling of greater satisfaction at the result of the working of the Company. The proceedings then ended.

City and South London Railway Company.

The eighteenth ordinary general meeting of this Company was held on Tuesday at Winchester House, Old Broad-street, under the presidency of Mr. Charles Grey Mott.

The SECRETARY (Mr. W. F. Knight) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: It now becomes my duty to move the adoption of the report and accounts. You will be pleased to see that the steady increase of receipts has continued during the past half-year, in spite of the long-continued fine weather, which you know, on most occasions, is detrimental to the traffic of this line. On the other hand, we have the satisfaction of stating that there has been no increase, but, on the contrary, a small decrease in the expenditure, so that we have an increased receipt with a decreased expenditure—always a satisfactory condition of things in all companies. Then, we have again to report that the line has been worked with the greatest regularity, and without any stoppage or interruption. The line itself, I think, is growing in popularity. The public find that it has an almost unexampled regularity of service and perfect punctuality; that it has a pure atmosphere, free from all noxious vapours; that it has an even temperature, which is pleasant both in summer and winter; and that, altogether, the line is one such as was wanted very much in the metropolis; while it is a great improvement upon all existing communications. I will now shortly call your attention to a few of the items in the accounts. In the first place, as regards the capital expenditure we have raised £17,050 during the half-year, which we have used in paying off liabilities amounting to £10,209, and in expenditure upon the Stockwell sidings and various other matters amounting to £6,181. Those items account for nearly the whole of the capital expenditure. We have paid off during the half-year £3,800 of the terminable debentures, and have replaced them by Four per Cent. Debenture Stock issued at a premium, so that we have effected a small saving there. The amount of debentures which fell due this half-year was exceeding small, but in the future we have a large amount maturing, and we shall have an increased saving each half-year until we get the whole of these paid off and converted. We now come to the most interesting account, the revenue account. The receipts from passengers have increased £1,491 in the half-year, and from season tickets there has been an increase of £36. Parcels receipts are £9 more, transfer fees show an increase of £4, from rents we have derived an additional £78, and sundry receipts have given us £21 more. You therefore see that there has been an increase in every department of receipts, making the total improvement for the half-year £1,639. On the other hand the expenses for maintenance have increased £13, but locomotive expenses have decreased £159; carriage repairs, as might be expected, have increased by £57, but traffic expenses have decreased £124. The general charges are £160 higher. I may state that the increase in general charges is largely due to what I think you will approve—that is, the insurance against accidents. We have thought that on a small line like this, although the liability to accidents is exceedingly small, yet still, in the early stages of the railway, it was not desirable to run any risk which might interfere with our dividend. We have, therefore, entered on an insurance against accidents, and by paying £200 a year this will insure us up to a limited amount, though a considerable amount, both annually and for each accident. I hope that the accident company may reap the benefit, and that we may have no claim on them, but I think you will agree with the Board that it was a prudent course to adopt. It is that, however, which has caused the increase in our general charges. We have had to pay this half-year £24 for passenger duty, which has not appeared in previous half-years. I daresay some of you have noticed that questions were asked in the House of Commons on this subject. The fact is that this matter has been under discussion for some time with the Inland Revenue Department. We issue no tickets, and we give every passenger the right to travel the whole length of the line. Our contention, therefore, was that we had no means of knowing how far a passenger travelled, and if he had the right to travel the whole length of line, he was not liable to duty, as it came to less than 1d. a mile. The Inland Revenue contended that a certain number—not a large number—did not travel a sufficient length to make the rate 1d. a mile. It was impossible on the part of either the department or ourselves to ascertain the number, and we eventually agreed on a compromised arrangement. The passenger duty is thus chargeable with £24 for what was due for the past half-year and one or two previous half years under that arrangement. The law charges have decreased £52, rates and taxes have increased £44, and compensations have decreased £117. The consequence is that there is a net decrease in expenditure of £134, which, added to the increase in the revenue, makes the net improvement £1,773. With regard to the increase in rates and taxes, that has been going on steadily, and I am afraid that we must look forward to a still further increase in the future. It has affected all railways in the country as well as individual householders. Unfortunately, there is a spirit abroad in this country of a retrograde nature, which is going back to the exploded theory of Cæsarism, by which everything is to be done for the people and nothing by them themselves. It has always been found in the past—and, no doubt, it will be found in the future—that that doctrine led invariably to a large increase of public expenditure, and at the same time took away that self-help and self-dependence which is the great strength of all nations. As long as that spirit is abroad you will see steadily year by year an increase of all rates and taxes, both Imperial and local; and until we have found out the mistake of our ways, I am afraid that we must look for a steady increase in that direction. You will be interested to hear the percentage of working expenses on this line—what it has been in the past, and what it is at present. In the first half-year the expenses were 79 per cent., in the second half 76 per cent., in the third half 70 per cent., in the fourth half 67·9 per cent., and in our fifth and last half 64·6 per cent. You therefore see that there has been a steady, regular decrease in the percentage of expenses to receipts. I hope that that will go on in the future as in the past, until we get the expenses down to a much lower rate than they stand at present. As I have pointed out before, these expenses include the item of the lifts, which is not an expense connected with other railway companies, who have no lifts. If you deduct the cost of working these lifts, our expenses, as compared with those of other railway companies, would be only about 56½ per cent. of the receipts, which is very nearly the same as those of many of the ordinary larger railway companies. It may be interesting to notice the changes which have taken place in the receipts per train mile on this line. We began our first half with a receipt of 2s. 1d. per train mile, in the second half it was 2s. 1½d., and in the third half it was 2s. 2½d. We then put on a large increase of mileage, the effect of which was felt by the receipts being reduced by 2d. per train mile. We have only put on this half-year a small additional mileage, and the result is we are overtaking the large addition of train mileage previously put on, and the receipts per train mile have risen to 2s. 1½d. The expenses per train mile, on the other hand, in our first half-year, were 1s. 9½d., in the second half-year 1s. 7¾d., in the third half-year 1s. 7¼d., in the fourth half-year they were 1s. 5¼d., and last half-year they were 1s. 4½d., which is going down at a very satisfactory ratio. Our locomotive expenses in our first half-year were 9d. per train mile, in the second half-year they were 7·9d., in the third half-year they were 7·7d., in the fourth half-year they were 7·1d., and this last half year they have been 6·48d. As I have pointed out to you on various occasions before, if you compare that rate of working of locomotive expenses with those of the large railways of England—such as the North-Western the Midland, the Great Western, and others—you must take off the carriage of the coal which we pay for and they do not. Deducting that, the locomotive expenses would be reduced to 5¼d. in the past half-year, which is very little more than half the rate which the large railway companies of England now pay for steam purposes. The receipts for each passenger in the first half-year were 1·90d., in the second half-year 1·70d., in the third half-year 1·73d., in the fourth half-year 1·60d., and last half-year 1·66d. These figures have varied mostly in consequence of the increase or decrease of the local short-passenger traffic. A year ago we tried in various ways to get a mid-day traffic, and a number of short distance passengers at low fares, and we were successful in that, but the result was that although we got a general increase in receipts, it diminished the receipt per passenger from 1·70d. to 1·60d. This half-year, however, we have a general increase in long-distance traffic, and the receipt per passenger has risen to 1·66d., or very nearly the figure it was before we made the reduction. The new sidings at Stockwell, referred to in paragrah 7 of the report, are practically completed, and will very shortly be brought into use. We are anxious to have them in use before the winter traffic commences, and they will be ready before that time arrives. I think they will enable us to give a somewhat improved service this winter. We have also, by putting on an additional signal between Stockwell and the Oval, been able to improve the service somewhat in the past half-year. Our Bill for the extension to Islington has passed the House of Lords. It has been read a third time, but has to go the House of Commons to obtain its consent to some alterations, and then it will remain for the Royal assent. In order to try and improve the King William-street station at the surface we have acquired the lease of the adjoining premises in Arthur-street East. The station at the surface is dark and confined at present, and it is very difficult, owing to the small space available, to make any improvement, but we have been very anxious to do so, and having the opportunity of acquiring the lease of the premises mentioned at a moderate price, we have availed ourselves of it, and are now considering what alterations we can make, at a small expense, by which we may somewhat improve the access at the top of King William-street station. I do not know that there is anything more that I need detain you with, and I beg to move that the report and accounts now presented to the meeting be received and adopted.

Mr. CHARLES SEYMOUR GRENFELL briefly expressed his pleasure in seconding the motion.

The resolution was at once carried unanimously, without discussion.

The CHAIRMAN then proposed a dividend at the rate of 5 per cent. per annum on the Preference shares for the half-year ended June 30th last.

Mr. SAMPSON HANBURY seconded the motion, which was carried unanimously.

The CHAIRMAN afterwards proposed the payment of a dividend at the rate of ¾ per cent. per annum on the Consolidated Ordinary Stock for the half-year ended June 30th last.

Mr. S. BARCLAY HEWARD seconded the motion, which was unanimously adopted.

The CHAIRMAN: That concludes the business, and I hope that each time we meet we may have an improved dividend to declare.

Mr. DRAKE then proposed a vote of thanks to the Chairman and Directors. The shareholders recognised that amid many difficulties—theirs being the pioneer electric railway of London, and therefore having to gain experience for all similar undertakings in the future—the undertaking was progressing, and they might congratulate themselves on the improved dividend and on having carried such an enormous number of passengers without injury to life or limb. The service had been extremely regularly and punctually performed with very few hitches in the half-year, and this was a fact which, in addition to the financial aspect, should give great pleasure to shareholders as well as to Directors. It would be well if the lighting of the carriages could be somewhat improved.

Mr. JOWETT seconded the motion,

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The motion was carried unanimously.

The CHAIRMAN: I beg to thank you very heartily for the kind way in which you have passed this vote. I can assure you that votes of this kind are the greatest encouragement to Directors in continuing to do their very best for the shareholders. When they feel that their efforts in the past have been appreciated, it makes them double them in the future; and I am sure that all matters connected with this railway will have our very best attention. It is a labour of love with some of us, and they intend to make the line a success—and a great success—before they have done with it. The lighting of the carriages is a matter that has engaged our attention perhaps more than anything else. It is an important question, but it is one of the most difficult we have to deal with There are difficulties which beset us on every side with respect to the lighting, but we are determined to overcome them, and we are busy now in making certain tests with this object. I look forward with confidence and hope to the future of this undertaking. Its progress may be slow, but it will be absolutely sure, to my mind; and if we go on in the future as we have done in the past, I feel sure that the day will arrive when none of you will be disappointed with the dividend.

The proceedings then terminated.

Edison and Swan United Electric Light Company (Limited).

The annual meeting of this Company was held on Friday, at the Cannon-street Hotel, Mr. J. Staats Forbes (Chairman) presiding.

The SECRETARY (Mr. H. Charles Gover) having read the notice convening the meeting,

The CHAIRMAN said: I think the essential part of the report is in a nutshell. And it is embraced in this—that the gross receipts of the year are the largest the Company have ever obtained, and that the expenses are exactly of the same description, for reasons which I will explain more fully presently, while the net profits of the year have increased by £11,831. The position of the Company is, as you know, now approaching a moment when there will be a considerable change. The period of protection will expire in November, and we should have been very much wanting in our duty to you if we had not anticipated that event for some years. We have been working on a well-considered design for a number of years, the design being that when we emerge from protection we shall be prepared for competition, of which I daresay we shall have some. This is the tenth complete year of our existence. and it is rather curious, and worth while calling your attention to the fact that, during the first five years, we paid no dividend at all, and we began the sixth year with an enormous incubus in the shape of a cumulative claim by the "A" shareholders of £121,000 in round numbers. During the past five years, the business having prospered, and the electric light having extended somewhat rapidly in comparison with the earlier years, we have been enabled not only to pay the 7 per cent. preferential dividend secured to the "A" shareholders, but to wipe out that large sum of £121,000. Therefore we emerge from the protected period having paid the preferential 7 per cent. for the whole of the ten years, while for this present year we propose to pay an additional 3 per cent.—making 10 per cent. If you will turn to the profit and loss account, you will see there is a credit balance of £86,642, and if you look at the statement showing the proposed appropriation of the profit you will see how we recommend the disposal of that amount. When we commenced the year the balance of arrears of the cumulative preferential dividend on the "A" capital was £8,261. That was the remainder of the £121,000 which we began with five years ago. That £8,261 had to be got out of the way, and we did it by means of an interim payment at the end of the first six months, in addition to which we paid 3½ per cent. for the half-year ended December 31st last, amounting to £12,371, on the "A" shares. Well, we now propose to make up the 7 per cent. preferential dividend for the year, which the holders of those shares are entitled to, and for the first time in the history of the Company the position of the Deferred, or "B," shareholders has to be taken into account. This £117,000 worth of shares represent the interest of Mr. Edison and his friends, and is the purchase price of the patents and the formation expenses of the Edison Company, and they are held subject to the condition that they participate to the extent of one-quarter in any profit of the undertaking after meeting the seven per cent. preference claim of the "A" shareholders. As you will see there is a considerable surplus after the payment of that seven per cent., and we have proposed to pay three per cent. over and above the seven per cent. distribution upon the "A" shares, and, of course, the same amount upon the "B" shares, which, for the first time, participate in the profits. I hope it will endure. We also carry over the very considerable sum of £39,498. Seeing what is before us, and the necessity of a pretty strong reserve, the Directors have deemed it prudent to err on the right side, and they think that having paid off all the accumulations on the "A" shares it would be wise to have a large reserve. The Board, therefore, have no hesitation in recommending a ten per cent. dividend instead of a larger one, which would be possible if we trenched further upon the profit of the year. What we have to consider, of course, is whether the profit of the year, as shown in the figures I have given, is likely to be maintained in the face of the competition which may be tolerably severe. Well, we have laid our plans so as to be prepared to face it. We shall not escape the inevitable, but we must endeavour to hold our own, and we think that with the good organisation, the large connection, the strong reserve, and the good name we possess, we may be able, if not to attain such large results as during the protected time, at all events to retain sufficient business to make our dividend a very fair and reasonable one. What it will be no man can tell, and I am not going to prophesy. We shall have to keep our eyes open and put our best foot forward during the next two or three years. With that view we have become manufacturers as well as lamp makers. For a very long time we were so bitten in the earlier years by the errors of the two Companies—the Edison and the Swan—in entering upon installation business and contracting for supplying light and so forth, the effect of which was so nearly disastrous that we determined not to touch that kind of business at all until we saw our way very clearly. Consequently, for a number of years we pursued the humble role of lamp makers. Latterly we have emerged into the business of manufacturers connected not with the lamp as a lamp, but with the appliances for its fitting and installation in houses and elsewhere. And although the lamps patents expire in November we have valuable patents in connection with the appliances which are already bringing in a considerable annual revenue, and which extend for a tolerably long term of years. In respect of these patents for holders and so forth we have commenced to manufacture for ourselves, charging ourselves the same royalty as we charge our licensees, and we have a great number of leading firms in the lamp fitting business, the gas fitting business, and the brass founding business who are competing with us in the sense that they are bound to sell at the same price as we do and to pay us a royalty on our manufacture. We found that the nature of the business required that that course should be followed. As I have said already, in the present development of lamps there is a considerable annual royalty coming in from that, which I have no doubt will grow rapidly from year to year, because it may be prognosticated with, I think, some degree of reasonableness, that electric lighting is now pushing ahead pretty fast and that the cheaper the lamp the more will electric light be used. While the lamp is sold at one price, under protection, people are probably more careful than if it was sold at some more moderate price in the open market. It will suit our purpose to have a considerable multiplication in the sale of lamps even if the price is lower than that which has ruled during the protected period. We must look to multiplication. The fixed charges of manufacturing are considerable and are not influenced by the number of lamps sold. You may double the number sold without increasing some of those items which form a tolerably fair percentage of the cost of carrying on business, and we have now obtained a position in which we can produce lamps as cheap as anyone in this country, or probably in Europe. Then the reputation of our lamps may be said to have been established. We can, of course, only induct from our experience. We had Edison lamps constructed in America, and our own, the Edison and Swan, constructed on Mr. Swan's methods in England; and although our customers were free to select which lamp they preferred, the Edison lamp has almost disappeared, which, at all events, is some sort of proof that the Swan lamp was not inferior to the Edison. Of course, when competition begins we shall have lamps imported from Germany and all parts of the Continent. Well, we know pretty well what other lamps are, and I dare say we have enough knowledge to be able to measure their possibilities; and although no doubt the number of lamps we sell may be affected, we must look to the general development of the business and to our being able to hold our own in the total output of lamps, which must be from year to year greatly increased, because it is only just recently that the electric lighting business seems to have moved. One has the opportunity of reading in the papers the speeches of gentlemen connected with electric light companies, and we have a natural interest in following their remarks. We read that the Westminster Company have 120,000 lights instead of 60,000, and that the St. James's have doubled theirs, and that the Chairman of the London Electric and the Metropolitan for the half-year or year, when he comes before his proprietors, is enabled to say that the number of their lights has increased by so many thousands. All this indicates the rapid multiplication of lamps. Hitherto we have had something like a monopoly, but not an entire monopoly, because in spite of the best endeavours a certain number of foreign lamps have got into the country, but not in any serious proportion. When the time comes we must endeavour to hold our own relatively to the general advance in electric lighting, and if the result is achieved, which I believe from my connection with the Company I can foresee—that there will be a great spurt in this business, an immense extension of it during the next few years—if that result is achieved what is now a comparatively small number of lamps will become an enormously increased number. I dare say gentlemen who walk about London with observation notice now two curious things. You see a house being redecorated or undergoing repair, or being built, and on the front there meets your eye the name of the builder, so-and-so, and also a board announcing that the electric light installation is by so-and-so. That is to be seen all round the squares and streets and down the tortuous lanes, and wherever you go. This state of things gives us hope of a growing business in the future, coupled with which we look forward to a large increase in the manufacturing business, which means a great number of interesting, necessary, and somewhat costly things, such as switches, pendants, holders, switch boards, and such like things, upon which, of course, the profit per article is considerably greater than upon such a very small implement as a lamp. We have also prepared ourselves for that. We have the premises, the skill, the experience, and the money at our backs—reserve, most of it. Having said thus much I think I have communicated sufficiently our position, warning you that there is the past, like there is in a man's life, a subject of retrospect, and the indefinite, which is a mere matter of speculation. There are one or two general things I should like to call your attention to. The gross income for the year, including the stock, you will see by the accounts, is £240,271, as against £212,048 last year, an increase of £28,223. The gross expenses have been £153,629, as against £137,237, or £16,392 extra, leaving an additional profit of £11,831. I have one or two observations to make about that £16,000. It is a considerable addition no doubt, but during the past year, for the first time, we have had to bear the burden of establishing a number of depôts. When we are competing with others, and our business extends, people who live in the great centres of industry would

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probably get tired of drawing their supplies from the factory at Ponder's End; and as a matter of fact, looking forward, we were determined to try the experiment of having a London depôt, and so we opened one in Parliament-street, Westminster, where we have done an extremely good business. At this depôt our lamps have been visible to passers by, with the result that customers have been attracted. We have become, in fact, traders in lamps on our own account, at the same time paying due regard to the interests of what is called the trade, because, of course, our business is to be all things, as far as we can, to all people. We do not feel it prudent to leave ourselves entirely in the hands of installers or traders. We have now an enormous *clientèle* over and above the trade, but, as a matter of course, we do make the trade certain allowances in the shape of discount, because the trade undertakes certain risks and relieves us of them. We are so satisfied of the wisdom of establishing these depôt that we have recently opened one at 110, Cannon-treet, where any of you gentlemen will be welcome to call and see what we have, and the multiplicity of articles on sale connected with the lamp business. We have altogether twelve of these depôts. Two are in London, and both are doing extremely well. Although the Cannon-street depôt has been opened only about a year, it has attracted a considerable number of customers, and I have no doubt that these different depôt are valuable adjuncts to our Company. In the provinces we have opened depôts at Birmingham, Cardiff, Liverpool, Leeds, Newcastle, Hull, Dundee, Glasgow, Belfast, and Dublin, and we are doing business in all these places, and look forward to its being increased. We have had the good fortune to be served by some admirable officers, amongst others a commercial gentleman who has charge of these different depôts, and whose business it is by means of advertising and travellers to bring our wares to the notice of the public. That sort of thing, of course, costs money, and of the £16,000 extra expenditure, £7,830 is attributable to the expenditure incurred in establishing these eleven new depôts. Of course, we hope that we are throwing a sprat to catch a mackerel. I think these depôts will be quite indispensable, because when the period of competition comes they will be one of the means of obtaining business in the great centres of industry. Another thing I have to call your attention to is our position with regard to the solid asset of the Company, by which I mean our tangible property. You know we were founded on patents, which we have had the enjoyment of for ten years, and, in a certain sense, for the preceding years of the life of both Companies, before they became one, and in which time they both made a pretty mess of their affairs. As a consequence we have had many thousands of pounds to write off these patents altogether, apart from any benefit you, as a united company, have had from them, before we were in a position to pay any dividends at all. The position is this. The "A" or Preferred capital of the Company is £353,478, which has a cumulative claim to a seven per cent. dividend before the "B" shareholders get anything, and it takes £24,743 to pay that 7 per cent. Besides the £353,478 which is subscribed capital, we have £117,820 worth of deferred capital in virtue of the benefits accruing from the patents. As these patents expire in November next there is not much value to be attached to them for the future. The holders of that £117,000 worth of capital are entitled to a quarter of anything earned after paying the 7 per cent. on the "A" shares. As I have said before, I hope they will get something, and I think there is a probability that they will. But we are more concerned with the people who found the money—the £353,000 odd. Now, of that amount we have got £200,000 in a solid asset in the nature of freehold property, plant and stock, debtors and Consols. Of course I am obliged to suggest that that asset is valued as part of a going concern. It is less than what it originally cost, because we have carefully, from year to year, written down these items, and £200,000 is much within the value of these things as long as they continue parts of a going concern. I do not mean to say that these different assets could be sold in the open market, like bread and butter, to-morrow morning and realise that amount. But the necessity of doing that is not within the bounds of immediate probability. Then it comes to this, is our position and experience, our capacity to supply any demand, and our trade mark worth the balance of our capital? You are as capable of judging that point as I am. I am sanguine enough to believe they are. I think we need be under no apprehension that our venture will cease to be certainly a reasonably profitable one, and probably a very profitable one, because with the multiplication of lamps we shall speedily retrieve the loss which may ensue upon the sale price when we emerge from our protected period. I do not know whether anyone will be curious upon the subject of the accounts. I shall be happy to enlarge on them, but I think they speak for themselves, and there are many gentlemen present competent to ask questions upon them. If anyone should desire an explanation of any particular item I shall be pleased to answer him. I think I have now said enough upon the question of the accounts and the position of the Company, and therefore I will move—

"*That the report and accounts for this year ended June 30, 1893, be received and adopted.*"

Major S. FLOOD PAGE (Deputy-Chairman) seconded the motion, which was unanimously agreed to without discussion.

The CHAIRMAN, in proposing the following resolution, which he described as one of the most complicated things he had ever had to deal with, said that the more critical shareholders would see that the amount of the dividends recommended in it was not quite in accordance with the figures in the report:—

"*That a dividend be and is hereby declared on the "A" shares of the Company of* 4s. 0½d. *per share on the* 89,261 *Ordinary shares,* £3 *paid; of* 6s. 8¾d. *per share on the* 5,000 £5 *fully-paid shares allotted to the Edison Electric Light Company (Limited); of* 5s. 0½d. *per share on the* 12,139 £5 *fully-paid shares allotted to the Swan United Electric Light Company (Limited); and of* 3s. 2d. *per share on the "B" shares of the Company; being, with the interim dividend paid on March* 14, 1893, *a payment on the "A" shares of the Company of the balance of arrears of cumulative Preferential dividend, and of* 10 *per cent. in respect of the year ended June* 30, 1893; *and on the "B" shares of the Company* 3 *per cent. in respect of the year ended June* 30, 1893. *All to be distributed in accordance with the provisions of Clause* 37 *of the Articles of Association, income-tax free.*"

Major FLOOD-PAGE seconded, and the resolution was carried.

Mr. H. R. HEDGES asked for some information with reference to the negotiations for the amalgation of the Company with the Swan Company. He also expressed the hope that if any such amalgamation took place it would have the effect of reducing the charges for administration.

The CHAIRMAN: I am glad the shareholder has asked me this question, as it affords me the opportunity of telling the meeting something about this matter. It is a subject we feel the importance of from year to year, and the importance of it becomes accentuated as the period for the expiration of our patents approaches. Our attention during the past twelve months has been given to it, and propositions have been formulated, and I suppose I may say substantially agreed to, setting forth the conditions upon which the Edison and Swan United Company are to take over the remainder of the business of the Swan Company. You are aware that the Swan Company hold 60 per cent. of the "A" capital of our Company, but that only represents what is called the British business. We retain for our own benefit what is termed the foreign business, and we succeeded in affecting a fusion with the French Edison Company, in which we hold a certain amount of capital, which has paid, during the few years we have been connected with it, a reasonable dividend. But we have never been able to succeed in Germany, where we had prolonged litigation, which prevented the use of our lamps. People there were threatened by us that if they used the Edison lamp they would be infringing our patent, and they were threatened by the Edison people that if they used the lamps made by us they would be liable to damages. That sort of thing went on a great many years, and then our patents were declared not to be an infringement of the Edison patent. After that result we made up our minds to continue our business in Germany until we could see our way to dispose of the whole thing. There are many complications which it will probably take a long time to render clear, but they all point to putting the remnant under the parent umbrella, and the terms are practically agreed to. Lord Lichfield and Sir John Lubbock, M.P., were good enough to act for the Edison and Swan United, and Mr. Quilter, M.P., and Mr. Swan acted for the Swan Company, and they have arrived at a certain conclusion which, however, cannot be carried into effect until a little internal matter has been settled. You know that we have in our Company a certain number of fully-paid shareholders and some partly-paid ones, so that when we come to sell the remainder of the business for a consideration we have to determine what a reasonable apportionment amongst the two classes of shareholders would be, and that is a rather difficult thing to do. It involves looking into the future, as the apportionment must be founded partly upon present values and partly upon an unknown quantity; that point has occupied the attention of the gentlemen to whom I have referred for a long time, but Mr. Quilter, representing, I think, more fully what I may call the partly-paid interest, and Mr. Swan representing more particularly the fully-paid interest, have come to an arrangement. At the first blush I confess I did not like the look of it, but when I heard the arguments I came to the conclusion that it was a reasonable and fair proposition, but the Directors can do nothing until the shareholders have agreed to it. We had a meeting yesterday of the fully-paid shareholders in the Swan Company to put the matter before them and we hope the arguments which satisfied them will meet with the approval of the general body when we can get them together. It will have to be submitted to an aggregate meeting, and then we shall have to submit the bargain to the shareholders of this Company. One of the objects of the proposed fusion is to effect economies in the administration, and there is every reason to believe that that result will be the outcome of it.

The retiring Directors, Major Flood Page and Mr. Bidwell, F.R.S., were then re-elected.

Messrs. Welton, Jones and Co. were also re-appointed auditors, and the meeting terminated with a vote of thanks to the Chairman.

Manchester Edison-Swan Company (Limited).

The eleventh ordinary general meeting of this Company was held on Friday, Mr. V. K. Armitage, Chairman of the Company, presiding. The annual report of the Directors, which was taken as read, stated that the net profit, including last year's balance, amounted to £2,047. 14s. 9d. Of this it was proposed to devote £1,000 to the payment of a dividend at the rate of 5 per cent. per annum, and £873. 15s. towards the loss incurred in connection with the Williamson Electrical and Engineering Company (Limited), of Australia, carrying forward a balance of £173. 19s. 9d.

The CHAIRMAN, in moving the adoption of the report, referred to the depressed state of electrical business and business in general during the past year, and said that the Manchester Edison-Swan Company had suffered a good deal through the delay of the Manchester Corporation in carrying out their installation, as people did not care to go forward with installations on their own account till they saw what the Corporation were going to do in the matter. The Corporation seemed now to be within measurable distance of the completion of their works. The net profits of the Company had been about £800 less than in the preceding year. Although the result was to that extent unfavourable, he was not without hope as to the future of the Company. There could be no doubt that there would be a very great spread of electric lighting in the immediate future, and they hoped and believed they would get their share of the work that had to be done. Nearly all the business they had done had been

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remunerative work, and with increased business they would have an increase in the amount of their profits.

The motion was seconded by Mr. W. P. JAMES FAWCUS, and after some criticisms on the accounts by Mr. C. Hopkinson, it was put to the meeting and adopted.

It was agreed that the profits should be disposed of in the manner suggested in the report, except that out of the balance to be carried forward, £150 was voted as remuneration to the Directors. Votes of thanks to the Chairman and other Directors concluded the proceedings.

Crompton and Co. (Limited).

The fifth annual general meeting of the members of Crompton and Co. (Limited) was held at the City Terminus Hotel, Cannon-street, on Monday last, July 31st, Viscount Emlyn presiding.

The SECRETARY (Mr. Francis R. Reeves) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said: Gentlemen, in rising to move the adoption of the report, although we meet you with a diminished dividend, I am quite sure that I am justified in congratulating you upon the progress and position of the Company. First, as regards the business done, I am glad to say that the turnover shows a satisfactory increase over the previous year, and the gross profits on trading an increase of nearly £3,800. This progress has been made in spite of the severe commercial depression which has affected (more or less) all classes of business, and consequently checked the receipt of orders for our goods. One country alone, Australia, which through our affiliated Company has formerly been a large customer for our goods, has taken very little from us during the past year. There are, however, now signs that this trade is likely to improve, the orders booked during the past three months being nearly equal to those for the whole of the previous year. The outlook from South Africa is also promising. During the past year the cost of manufacturing goods at the Chelmsford works has again been considerably reduced, and, in fact, so far as regards economy of management, the Directors feel that they have every reason to be satisfied with the progress made in this direction. Unfortunately, the year has suffered from some exceptional and unforeseen expenses, the principal of which were those attending the temporary arrangements consequent on the breakdown of the boilers at Chelmsford Works. The water supply there, though expensive, is unsatisfactory in quality, and the boilers, when the heavy pressure of the town lighting came on last winter, gave out altogether, and before new ones could be got in to take their place temporary boilers had to be hired and put into position at great expense in order to keep the works and the town lighting plant going. Since this trouble the Directors have got new boilers into position, with water-purifying plant, and substantial savings are now being made in this department. Another item of expense beyond the normal amount has been the cost of advertising and exhibitions. This account is being closely watched, so as to effect considerable reductions during the current year. The extraordinary general meeting of the shareholders last October sanctioned the nominal increase of capital of the Company to £300,000. The cost of registering this capital, and the expense of issuing prospectuses and advertising, have been temporarily charged to a suspense account, and will be written off in equal instalments in about three years. Since the last meeting 2,781 Preference shares and 1,928 Ordinary shares have been placed. The list of applications for Debentures has also been closed, and the Committee of the Stock Exchange have granted a quotation in the Official List for these securities. This is an evidence that all formalities have been properly complied with. The stock-in-trade shows a considerable increase over the previous year, a satisfactory feature, as the increase, consisting as it does mainly of finished parts of the machines, enables the Company to make quick delivery, and this fact often secures an order. The item "Trade Debtors" shows an apparent decrease. This is due to the transfer of the Chelmsford lighting account to "Investments." With regard to the "Profit and Loss Account," for the reasons already mentioned, the net profit is some £3,000 less than last year, and the Directors do not, therefore, recommend the full dividend on the Preference shares. They feel sure, however, that the shareholders will agree with them that this is the proper course to adopt. As far as the Preference holders are affected, I may point out that their dividend is cumulative, so that the balance (1 per cent. for the year) which is unpaid now is carried forward to next year, and is a first charge after Debenture interest on the future profits of the Company. The Board have every confidence in the future. The works at Chelmsford and at Lillie-road are in first-rate order and well equipped. The Company has a good staff of engineers and officials, most of them old hands, and is served by an excellent body of workmen. It will be gratifying to the shareholders to learn that the Crompton arc lamp has been so improved by the efforts of the staff that it now holds the position of being the best and cheapest in the market, and that very considerable orders have been received for these lamps. That gentlemen is, I think, the whole of the story that I have to tell you. I have endeavoured to put before you clearly and in a few words the exact position of the Company, and I hope that the shareholders will agree that in this somewhat peculiar year in which we had exceptional difficulties to meet that we have done our utmost for the best interests of the share holders. I beg to move:—

"That the report of the Directors and statement of accounts to March 31 1893, be received and adopted."

Mr. R. E. B. CROMPTON, one of the Managing Directors, said that in rising to second the resolution just proposed by the Chrirman, he did not propose to say many words, as being Managing Director he was very largely responsible for the state of things and the diminished dividend, he did not want to put forward excuses. He would simply say that they had not made as good a year as they felt that they ought to have done. But the causes had been beyond their control. Bad trade generally had had a great deal to do with it as well as the expenses in connection with their boiler department—causes which were sufficient to account for the reduced dividend. But he could corroborate every word that the Chairman had said calculated to lead the shareholders to believe that this state of things ought not to diminish the profits in the future. He thought that everybody would admit that the period of depression in all kinds of trade which they were now passing through had reached the point at which they might at least hope for a turn of the tide, and he did not think that their Company would be unfitted to take advantage of the revival. It had been the great aim of the Managing Directors to look for every possible means of providing steady work for their Chelmsford shops, which would be in the nature of a backbone to the business. The manufacture and sale of dynamos had always been a part of that backbone. Although Crompton and Co. had for many years past been manufacturers of arc lamps, for the last six or seven years that had been quite an insignificant item in their business, the wages paid having been only a few hundred pounds per annum. So that now, as the Chairman had told them that they had suddenly as it were, developed the arc lamp, it made him, as a Managing Director, very hopeful that they had discovered a second string to their bow in the shape of the manufacture of an article which could be carried on in good as well as in bad times, and for which there would be an increasing demand when the normal state of affairs came round again. He thought, as to the demand for this new arc lamp, from what they had seen, that during the ensuing year it promised to yield something substantial towards the year's profit. He had no doubt they expected him say something regarding the heavy cost of the boilers. He was afraid he could not satisfy them much on this point. It was more in the nature of a pure accident that the boilers gave out as they did. They well knew that the demand, in consequence of the lighting at Chelmsford, added to the ordinary pressure on their works, would be very considerable last winter; but they did not reckon on the extreme badness of the water supply which damaged their old boilers before the new ones could be placed in position. Hurried work had to fill up the gaps between the failure of the old and the fixing of the new boilers which was a costly operation, and it was a very anxious thing for the Managing Directors to see money paid away weekly which they knew must come out of dividend. He thought, however, that they had taken steps to prevent the possibility of anything of the kind occurring again. Of course accidents might happen, but they had taken all possible means to prevent them. They had adopted the type of boiler best suited for very bad water, and in addition to that they had put down purifying plant. They had, moreover, taken advantage of this change to put up boilers which would enable them to use cheap coal, and thus the troubles which they had had in the past might be a source of profit to them in the future. He honestly believed that the cost of fuel would be much lower than it could have been with the old boilers, so that out of evil came good. They were watching this matter very carefully. They had a return drawn up every week, and from the commencement of the present year there had been a steady decrease of the expenses under this head. He could only say that the hard state of affairs affected the Managing Directors more than it did anyone else in the Company, and, therefore they had the sharpest spur put in them to see it improved as soon as possible. No one could regret more than he did that the shareholders did not receive their full dividend. He begged to second the motion.

Colonel WOOD suggested that they should increase the depreciation fund so as in future to cover any accidents that might occur to the boilers.

Mr. KITCHIN said that they must all agree that the report was an unfortunate one in many ways. A great deal of the eloquence of the Chairman and Mr. Crompton had been directed to the fact that their position was bad because trade was bad throughout the country. They all imagined that they were engaged in business which had felt that condition of things; but if there was one company which had not felt it it was Crompton and Co. (Limited). Consequently, the nature of the business and not the quantity of it had to do with their present position. He ventured to think that it was very largely due to unwholesome competition. But he would like to ask one or two questions in reference to that. First of all he would like to know whether the Chelmsford contract was paying; second, how long the lighting had been in progress there; third, at what date the boilers gave out; and fourth, what was the amount expended in making good the damage to the boilers. They had in the report a very vague statement that a certain amount had been spent, but he thought that the shareholders were entitled to ask what was the amount of extra expenditure which they had to face this year in making good the boilers so as to carry on the work—he hoped for 10 or 15 years—without further need for renewal. The sum, he observed, was to be charged to one year. Why this should be so he did not know unless there was some special reason for it. It was capital expenditure. He thought also that the enormous increase in the stock-in-trade deserved consideration. He understood that they were manufacturing dynamos available for future use. He would like to see some profit for the shareholders. He could quite understand that it might be necessary for a manufacturing company, in order to take a large contract to take an interest in other companies by taking their shares, but unless they were to get some return on the money they put in they had better be without the contracts dependent on such a proceeding. Therefore, he asked the Chairman to be kind enough to say what the investments of the Company were, and whether he thought it necessary to have such a large stock-in-trade.

Mr. BLAXLAND asked how they paid the interim dividend in view of the facts which had just been disclosed.

The CHAIRMAN said that the Directors were always obliged to any gentleman for criticising their acts in the friendly spirit in which it had been done that day. In reply to the question put by Colonel Wood, he understood that gentleman to say that they ought to increase the amount for

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depreciation so as to cover such accidents as might occur to the boilers. He believed that the boiler plant was insured, and the depreciation was put down at the full amount considered necessary, it had been increased this year by £500. It was quite sufficient to meet all ordinary accidents and wear and tear. He did not quite say that it would cover every accident; but the suggestion of the auditors was followed in the matter. Mr. Kitchen had pointed out that it was not so much bad times as the nature of their business that adversely affected them. The business, however, showed a very satisfactory result. If they took their gross returns they were very satisfactory. If it had not been for the exceptional circumstances which had been referred to they would have had a very satisfactory year; but he thought that they were justified in pointing out that they had succeeded in doing what they had done in spite of bad times and bad trade. As to the Chelmsford contract, the lighting was going on satisfactorily. The public lighting is not profitable but the private lighting shows a very fair margin and the number of lamps is steadily increasing. They hoped that in a short time it would be put on fair commercial lines—perhaps within this year. With regard to the cost of the break down of the boilers, they had had to spend a considerable amount for temporary work so as to enable them to carry on the business, in spite of what had happened. He thought that it put them to an outlay of about £2,000, which could only be dealt with as temporary expenditure. That was entirely apart from an expenditure of capital. The fresh boilers and water-purifying plant were entirely outside that. The question how they should charge the amount was one which greatly exercised his mind, and he was not sure that Mr. Kitchen would not support him in charging it over a term of years. He was quite sure that they would be justified in doing it. Still, they thought that they had done the wiser thing in facing the whole difficulty this year, although it did reduce the dividend. With respect to the increase of stock, that was a question which cut both ways. They had been trying for some time to have sufficient stock in hand to meet orders when they happened to get one in a hurry, so as to be able to carry it out promptly. If they were low in stock there was a danger of losing business. Whether they had reached the medium of having not too much or not too little it was difficult to say; but, at all events, it was satisfactory to know that they had sufficient finished machines in stock, which would enable them to deal with orders as they came in, and to secure others which they might otherwise lose. With regard to the investment of shares in other companies, no one felt more strongly than he did, that they ought to be very careful when they dealt with that matter. It was quite true that the requirements of the trade and the general business done might lead them to obtain orders by so investing in other companies, and it was sometimes an advantage for this reason to have an interest in these; but they were very adverse to such a policy unless they saw their way to get some good return for the outlay. The date at which the boilers gave out was January last, when they had no idea that anything of the kind was to occur. The question of the interim dividend had been raised by Mr. Blaxland. When they dealt with the interim dividend they could deal only with the figures before them. As he had already pointed out, and he hoped satisfactorily shown, if it had not been for the exceptional circumstances referred to their net receipts this year would have been exceedingly satisfactory. The difference between the net and gross receipts, as far as the dividend was concerned, was brought about by these causes, and these exceptional circumstances were not known at the time the interim dividend was declared. It was quite impossible for the Board to foresee them. They had power by the Articles of Association (Section 85) to pay the said dividend. As far as the Preference shares were concerned, as he had said at the beginning of the meeting, their interest was a cumulative interest, and it was only a question of postponing the payment of 1 per cent. for a year, when their claim would be prior to that of any others. There was a reserve fund upon which they could have drawn for this purpose, but they thought that it was better not to encroach too much on it.

Mr. KITCHIN: There is one more question I should like to ask before you put the resolution. I notice that the Auditor's certificate is qualified by the words "subject to our report of this date." Now this may mean there is something concealed which we ought to know, and I should like an explanation.

The CHAIRMAN: In the former year's certificate, the Auditor's words were "as per" instead of "subject to" their report. He did not know what the difference really was, but the words "subject to" certainly implied a reservation. He thought it would be more satisfactory if he read the report, which was as follows: "We beg to report having completed the audit of accounts for the year ended March 31st last, and hand you herewith the balance-sheet to that date with our certificate attached. We notice a large increase in the Company's holdings in various undertakings, which have been from time to time fostered or supported by your Company. It is not possible for us to exercise a judgment upon the value of such assets. But we desire to call attention to the fact that many of these have not yet reached a dividend paying condition, and are, therefore, *prima facie*, not worth their par values. We also notice that there are large amounts due from these same companies, which stand under Sundry Debtors in your balance-sheet. The stock has been certified to us by Mr. James W. Rooke, foreman of the stores department, and the capital expenditure, together with the expenditure on experimental work by Mr. Crompton, one of the Managing Directors." That is all there is in the document. He had already explained about the Chelmsford Lighting Company, and no doubt other companies which are new undertakings will also pay shortly—of course, the moneys due from those companies under the contracts with them are included in Trade Debtors.

The motion was then put to the meeting, and carried unanimously.

The CHAIRMAN next moved—

"*That a dividend at the rate of 2s. 6d. per share for the half-year ending March 31, 1893, making, with the interim dividend already paid, 6 per cent. per annum, be declared and paid on the Preference shares.*"

Mr. J. F. ALBRIGHT seconded the motion, which was agreed to *nem. con.*

On the motion of the CHAIRMAN, seconded by Mr. CROMPTON, the retiring Director, Mr. H. H. J. W. Drummond was unanimously re-elected.

Mr. R. PAYNE proposed, and Colonel JAMIESON seconded, the re-appointment of the auditors, Messrs. J. H. Duncan and Co., which was also agreed to without a dissentient.

A vote of thanks to the Chairman, moved by Mr. T. R. TUFNELL, and seconded by Colonel JAMIESON, who said the explanations given were perfectly satisfactory, was cordially passed, and the CHAIRMAN having briefly acknowledged it, the proceedings ended.

Electrical Power Storage Company (Limited).

The following report is issued by the Directors of this Company for the period ended May 31st last:—

The profit, after payment of general expenses, management, &c., is £5,245. 2s. 2d., from which the Directors have, in deference to the wishes of the Auditors, deducted a sum of £1,500, writing that amount off the patent account, leaving, with a balance of £626. 7s. 7d. from last year, an amount of £4,371. 9s. 9d. available for distribution, out of which the Directors recommend the payment of a dividend of 5 per cent., leaving £158 19s. 5d. to be carried forward. Provision has also been made for maintenance of buildings, plant, tools, &c., by writing off the sum of £2,083. 18s. 9d. The Directors are pleased to be able to report the continued success of the Company's operations; a considerable reduction in the selling price of its manufactures has been made, for the purpose of bringing storage batteries into more general use.

Particular attention has been devoted to securing such inventions as would tend to cheapen production while combining maximum efficiency and durability; and with this object several new patents have been acquired, and sole licenses for others have been obtained. Constant attention has been also given to the development of electric traction, for which the Directors expect a considerable demand will shortly arise. The Company and its licensees have been successful in patent litigation abroad.

The fourth ordinary general meeting of the Company was held at the offices, 4, Great Winchester-street, E.C., on Thursday last week, Mr. J. Irving Courtenay (Chairman of the Company) presiding, and we have been supplied with the following account of the proceedings:—

"The SECRETARY (Mr. J. W. Barnard) having read the notice convening the meeting,

"The CHAIRMAN said: In making some observations upon the accounts I desire to point out that the difference in the balance carried forward from the trading account this year and last year is mainly owing to proper deductions having been made in balancing the trading account, the discounts and other charges having been deducted before bringing forward the balance. The gross amount of orders is larger than last year, but owing to the reduction in price, and increased discounts to the trade, the cash received is rather less. But you will also notice that, in consequence of economies having been introduced into the management and into the manufacture, the net profits are practically the same, because from the amount of the profits we have written off this year £1,500 towards depreciation of patents. The Company is selling more of its manufactures than it did, and thus it is increasing its goodwill and obtaining a larger business with the public, because the objection taken in past years to the high price of accumulators have been to a considerable extent removed by the reductions in question. You are all aware of the depressed condition of trade, and that the electrical industry, like all other businesses, is suffering from the depressed times, but I am glad to say that the E.P.S. Company has done well, in spite of this almost unprecedented depression. We do business with all the leading firms, and the result is that whatever business is going we get a share of. We have competition to contend against, and no doubt shall always have, but I think by the improvements that have actually been made, and those we have in contemplation, and by the economies these will effect in the manufacture of the batteries, we shall be able to hold our own. We are, as you are aware, also acquiring patents for details in manufacture, and so in reality, though the basic patents are growing older, we are strengthening the position by these newer patents. One of the most vital questions for the E.P.S. Company is traction. You know that this Company associates itself almost entirely with what is called self-contained traction, and has endeavoured to develop it, though up to the present not with the results we aim at; but we do not for one moment despair of ultimate success. A portion of the expenditure in legal charges was incurred in what at one time looked a hopeful business, in endeavouring to obtain an Act of Parliament in an important provincial town for an electrical tramway. We failed because we could not get the necessary agreements confirmed in time for Parliament, and so the Bill was dropped. But we are persevering (not in that particular locality) with self-contained traction, and you have heard of a small company that has been formed—I refer to the Pioneer Electric Carriage Company—to develop a form of traction with novel features, among which is the pneumatic wheel. Some few of our friends have put their money in to test it, and, if successful, it will be a great benefit to the E.P.S. Company, and bring a wide demand for its batteries—such is the interest the E.P.S. has in the welfare of that concern. I do not think I need trouble you with any further remarks, and conclude by saying, so far as is possible to see ahead in these days, I entertain no doubt that the E.P.S. Company will continue to prosper. He then moved, 'That the Directors' report and statement of accounts to May 31, 1893, be and are hereby approved and adopted, and that a dividend of 5 per cent. on the paid-up capital be declared, payable on August 24, 1893.'

"Sir DANIEL COOPER seconded the motion.

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"Mr. J. W. BARCLAY: I do not intend to offer any criticism of the accounts, but to refer to a point which invites attention, viz., the use of accumulators for propelling carriages. Shareholders of the Pioneer Electric Carriage Company are endeavouring, at their own expense, to develop a system of self-contained traction for ordinary carriages. If the attempt prove successful a very wide field for the use of accumulators will be opened up. Meanwhile, the problem we have before us is to prove that this new method of locomotion is useful commodious, and economical. The operation of the Pioneer Company should certainly encourage shareholders to be hopeful for the future of the electric storage battery industry.

"The resolution was carried unanimously, and the retiring Director, Sir Daniel Cooper, Bart., G.C.M.G., having been re-elected, other formal business was concluded.

"In responding to a vote of thanks, the CHAIRMAN observed: I should like to say I have waited for this opportunity of expressing our indebtedness to Mr. Frank King and the staff for the keen and intelligent energy with which they have pushed the business of this Company. The Directors will bear me out when I say that Mr. King and his staff spare no effort to promote in all directions the interests of the E.P.S. Company.

"Mr. FRANK KING: On behalf of the staff and myself I beg to thank the meeting and the Chairman. It is our duty to convince engineers and others that the Secondary Battery, as manufactured by this Company, is the very best battery, for all purposes, they could possibly desire. We have been successful in this, and it is a great satisfaction to us to know that our efforts are appreciated.

"The proceedings then terminated."

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1893, pages 320-348, *&c., &c.*]

FRANK W. CLARK AND CO. (LIMITED).—This Company was registered on July 26th, with a capital of £10,000, in £1 shares, to (*inter alia*) acquire and deal with patents and inventions relating to the manufacture, purification, improvement, consumption, and distribution of gas or electricity.

GENERAL ELECTROLYTIC PARENT COMPANY (LIMITED).—This Company was registered on July 31st, with a capital of £24,000 in £1 shares, to ratify an undated agreement with James Hargreaves, Thomas Bird, John Hargreaves, Albert M. Gibson, and Arthur C. Bulkley Praed, for the acquisition of patents for "Improvements in Electrolytic Cells and Diaphragms," and for "Improvements in the manufacture of alkali and in apparatus therefor," and provisional specifications for "Improvements in the production of alkali and in apparatus therefor, the said apparatus being for electrolysis generally," for "Improvements in and in the making of electrolytic apparatus," for "Improvements in the electrolysis of iodides, bromides, nitrates, and other salts," for "Improvements in the electrolysis of chlorides, iodides, bromides, nitrates, and other salts and apparatus therefor," and to develop and turn to account the same.

INCANDESCENT ELECTRIC LAMP COMPANY (LIMITED).—This Company was registered on July 25th, with a capital of £25,000 in £10 shares, to carry on the business of manufacturers of, and dealers in, electric lamps, fittings, appliances, and materials, to generate, accumulate, distribute and supply electricity, for the purposes of light, heat, motive power, &c., to construct, lay down, establish, fix, and carry out all necessary cables, wires, lines, accumulators, lamps, and works, and generally to carry on the business of an electric light, heat, and power supply company, in all or any of its respective branches. The subscribers are:—

	Shares.
Gustav Binswanger (General Electric Company), 71, Queen Victoria-street, E.C.	100
Hugo Hirst, 71, Queen Victoria-street, E.C.	10
A. W. Boyce, 68, Inverness-terrace, W.	60
J. Fraser, Tregarthyn, Eton-avenue, N.W.	100
G. R. T. Fraser, The Limes, Hampton Wick	10
J. Fraser, jun., 81, Castleton-road, N	10
J. W. S. Dower, 17, Park-square East, Regent's Park, N.W.	50
E. Howe, 1, Lowndes-square, S.W.	10
T. H. Riches, Yelverton, South Devon	100

The first Directors are James Fraser, Gustav Binswanger, and C. J. Robertson (Technical Director).

ALLEN, EVERETT, AND SONS (LIMITED).—When the annual return of this Company was filed on June 29th, 10,000 Preference and 12,000 Ordinary shares of £10 each had been subscribed for, 3,300 of the Preference and 4,000 of the Ordinary had been issued as fully paid, while the full amount had been called on the 6,700 Preference and £8 per share on the 8,000 Ordinary shares. The calls paid amount to £131,000. The nominal capital is £300,000, divided into 10,000 Preference and 20,000 Ordinary shares of £10 each.

ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—Mr. Justice Vaughan Williams on Wednesday ordered the voluntary winding up of this Company to be continued under the supervision of the Court.

GREENWOOD AND BATLEY (LIMITED).—The annual return of this Company made up to July 1 has been filed. The nominal capital is £400,000, divided into 14,000 £7 per Cent. Cumulative Preference, and 26,000 Ordinary shares, all of £10 each, 11,065 of the former, and 18,052 of the latter class have been taken up, of which 2,666 Preference, and 4,666 Ordinary, have been issued as fully paid. Upon 9,600 Preference and 16,850 Ordinary the full amount has been called (or considered as such), while upon the remaining 1,456 Preference and 1,252 Ordinary shares £3 per share has been called, resulting in a total payment of £198,834.

HERCULITE AND ELECTRICAL MANUFACTURING COMPANY (LIMITED).—The statutory return of this Company, made up to May 25th, has been filed. The nominal capital is £12,000, divided into 4,000 Preference and 8,000 Ordinary shares of £1 each. 1,953 of the former and 4,000 of the latter (issued as fully paid) have been taken up, the full amount having been called on the Preference shares. The calls paid amount to £1,958 (which includes a sum of £25 paid on 50 forfeited Preference shares), leaving £25 in arrears.

HOME TELEPHONE COMPANY (LIMITED).—The return for 1893 states that the whole capital of £500, in £5 shares, has been subscribed for, £2 per share called, and £200 paid.

INTERNATIONAL OKONITE COMPANY (LIMITED).—The return of this Company, made up to January 24th, was filed on June 26th. The whole nominal capital of £340,000, divided into 17,000 Ordinary and 17,000 Preference shares of £10 each, was allotted; 11,332 shares have been issued as fully paid, and the full amount called on the remaining shares. The calls paid have realised £225,665, leaving £1,015 in arrears.

KEIGHLEY ELECTRICAL ENGINEERING COMPANY (LIMITED).—The statutory return of this Company, recently filed, shows that out of a nominal capital of £10,000, in £1 shares, 4,083 shares have been taken up, and 3 300 issued as fully-paid. The full amount has been called on the remaining 783 shares, resulting in the payment of £728, and leaving £55 in arrears.

LATIMER CLARK, MUIRHEAD AND CO. (LIMITED).—The annual return of this Company made up to July 21st has been filed. 4,709 £10 shares of a nominal capital of £100,000, in shares of £10 each have been taken up, the full amount called, and all calls paid.

LONDON BATTERY COMPANY (LIMITED).—At meetings held on July 11th and 26th a resolution was passed and confirmed that the Company should be voluntarily wound up, and that Mr. H. G. Ellis be the liquidator.

J. H. PICKUP AND CO. (LIMITED).—The annual return of this Company, made up to June 14th, has been filed. The 3,000 shares of £5 each, constituting the nominal capital, have been taken up, 800 being issued as fully-paid, and £3 per share called and paid on the remainder.

THORNEBURRY MINERS' SAFETY LAMP COMPANY (LIMITED).—It was resolved at meetings held on June 27th and July 18th to wind up the Company voluntarily, and Mr. F. Newton, 9, Warrington-crescent, Maida Vale, was appointed liquidator.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended July 30th were £822, as against £735 for the corresponding period of last year, being an increase of £87. The total receipts for the half-year amount to £3,425, against £3,021 in the corresponding period of 1892, being an increase of £404.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—A half-yearly dividend at the rate of 8 per cent. per annum is proposed by the board. The estimated traffic receipts of this Company for the month of July are £3,000, as compared with £3,194 in the corresponding month of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of July amounted to £62,317, and to £49,117, in the corresponding period of 1892, an increase of £13,200.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of the Eastern Extension, Australasia and China Telegraph Company (Limited) for the month of July, 1893, amounted to £45,376 and to £41,714 in the corresponding period of 1892; increase, £3,662.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The ordinary half-yearly meeting will be held at the Law Association Rooms, Cook-street, Liverpool on Tuesday next, the 8th inst. We gave an abstract of the Directors' Report in our last issue. A special general meeting is to be held immediately afterwards, when a resolution will be submitted authorising the issue of 4,500 Five per Cent. Preference Shares of £10 each, the unissued portion of an authorised issue of 12,000 Preference shares.

STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to allow the following securities of the National Telephone Company (Limited) to be quoted in the Official List:—Further issues of 25,730 Ordinary shares, Nos. 453,868 to 484,597; 28,284 Five per Cent. Non-cumulative Third Preference shares, Nos. 90,951 to 119,234; £198,540 Four and a-Half per Cent. Debenture stock.

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VENEZUELA TELEPHONE AND ELECTRICAL APPLIANCES COMPANY.—Coupon No. 6 of the Five per Cent. First Mortgage Debentures, due July 31st, will be paid from that date at the Consolidated Bank, Threadneedle-street, or at the banking house of Westendorp and Co., Amsterdam.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended July 28, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,784.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 26.	Price Wednesday, Aug. 2.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 2. Highest	Lowest
			TELEGRAPHS			£ s. d.			
£1,134,640	Stock	12,6	Anglo-American xd	49½ 50½	48½ 49½	5 11 1	Jan. Apr., July, Oct	49¾	..
£2,932,680	Stock	25/0	Do. Preferred xd	93 94	91½ 92½	5 18 11	" "	93½	91½
£2,932,680	Stock	5/0	Do. Deferred	9½ 9¾	9 9½	..	.. ..	9¾	9⅜
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	99 102	99 102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	11⅜ 12¼	11⅜ 12½	5 6 1	Mar., June, Oct., Dec	—	—
£36,400	£100	5%	Do. 5 per Cent. Bonds x2	101 104	99 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107 111	107 111	4 10 1	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	138 142	..	4 18 7	April and October..	..	..
16,000	10	8/0	Cuba Submarine	11½ 12½	11½ 12½	6 8 0	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	18½ 19½	18½ 19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½ 3½	2½ 3½	4 11 5	April and October..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	11⅜ 12	11⅜ 12	5 16 8	Jan., Apr., July, Oct	12	11⅜
400,000	10	5/6	Eastern xd	15 15½	14⅜ 15	4 6 8	" "	15	14¼
70,000	10	6%	Do. 6 per Cent. Preference xd	16½ 17	16½ 16¾	3 11 8	" "	16¼	..
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112 115	112 115	3 9 7	May and November	114½	..
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899 xd	108 111	106 109	4 11 9	February & August	..	..
250,000	10	2 6	Eastern Extension	15½ 15⅝	15½ 15⅝	4 11 1	Jan., Apr., July, Oct.	15⅝	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock xd	113 116	111 114	3 10 2	February & August	..	..
£70 6 10	100	5%	Do. 5 p. c.(Austln. Gov. Sub.) Debs 1900..	102 105	102 105	4 15 3	January and July ..	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb.,1900	101 104	101 104	4 16 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909(regd.) xd	102 105	101 104	3 16 11	February & August	..	..
£200,000	£25	..	Do. 4% Mauritius Sub. Debs.	3½ 3¾	1 3½ 10⅜	..	May and November	..	..
180,227	10	4,0	Globe Telegraph and Trust xd	9½ 10	9½ 9¼	4 12 4	Jan., Apr., July, Oct	9¾	9½
180,042	10	6%	Do. 6 per Cent. Preference xd	15½ 15⅝	15½ 15¼	3 17 5	" "	15⅝	15⅜
150,000	10	5 0	Great Northern	19½ 20	19½ 20	4 5 0	Jan., April, and July	..	..
£.0 0,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105 108	105 108	4 12 7	March & September	..	..
17.000	25	37/6	Indo-European	39 42	39 42	5 19 1	May and November	..	..
37,548	10	4/0	London Platino-Brazilian	4 6	4 5	4 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs.	100 103	100 103	3 17 8	" "	..	..
11,802	8	4/0	Reuter's	4½ 5½	4½ 5½	..	April and October..	..	..
3,381	£100 Cert	30.0	Submarine Cables Trust 6 per Cent.	118 123	116 121	4 19 2	" "	..	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July ..	..	..
£60,900	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	3 4	3 4	..	January and July ..	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	97 101	97 101	7 18 5	June and December	98	..
88,321	10	6d.	West India and Panama	1½ 1⅝	1½ 1⅝	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 11	10½ 11	5 9 1	May and November	10½	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1907	105 108	105 108	4 12 7	June and December	..	..
64,242	15	4 6	Western and Brazilian	7 7½	7 7½	5 0 0	May and November	7½	..
33,129	7½	4 6	Do 5 per Cent. Cumulative Preferred	5⅞ 6½	5⅞ 6½	..	..	6	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1½ 2	1½ 2	..	..	..	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910 xd	106 109	103 106	5 13 2	February & August	107	..
£222 700	100	6%	Do. 6 per Cent. Mort. Debs.,Series "B" 1911 xd	106 109	103 106	5 13 2	" "	..	..
£1,214,000	£1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120 125	120 125	5 12 0	May and November	..	..
£ 69,0 0	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	100 103	5 16 6	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	2 3	2 3	..	..	—	..
22,500	14/0	3½d.	Consolidated Telephone Const. & Maintenance	¾ 1	¾ 1	..	May and November	..	..
20,000	£1	4½d.	Oriental (11s. paid)	¾ 1	¾ 1	7 18 2	Yearly	..	..
458,867	5	2/6	National xd	4⅜ 4⅝	4½ 4⅝	5 5 3	June and December	4⅝	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref. xd	14⅜ 15½	14½ 15	4 0 0	" "	..	—
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid) xd	14½ 14⅝	14 14½	4 2 9	" "	14⅞	..
90,950	5	2/0	Do. 5% Non-Cumulative 3rd Pref.	5⅜ 5⅝	5¼ 5½	4 10 11	.. ..	5⅞	5¼
726 477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	110 114	111 113	3 19 8	January and July ..	113	112½
58,000	5	1/0	United River Plate	2 2½	2 2½	..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	10¾ 11¼	10¾ 11¼	—	—	..	..
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½ 13	12½ 13	..	—	12¾	12½
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	—	—	—
£150,000	£5	..	Electricity Supply Company Ordinary	.. ..	.. ..	..	—	..	—
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	—	..	—
8,32:	£5	..	House to House Electric	.. ..	— —	..	—	—	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	.. ..	..	—	..	—
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July ..	..	—
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4⅛ 4⅞	4⅛ 4⅞	..	..	..	—
15,000	£5	5/0 '92	Do. (fully paid)	6½ 6⅝	6½ 6⅝	..	..	..	—
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	..	..	—
49,000	£10	4/0	Metropolitan Electric Supply (fully paid)	6 6½	5¾ 6½	3 4 0	..	..	—
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102 105	102 105	4 15 3	June and December	103¾	..
6,452	£10	..	Notting Hill Electric	5 6	5 6	—	—	..	..
19,980	£5	9½%	St. James' and Pall Mall	6½ 7	6½ 6⅝	..	—	6⅝	6½
20,000	£5	7%	Do. 7 per Cent. Preference xd	8 8½	7¾ 8½	4 4 10	—	7½	..
59,900	5	1/6	Westminster Electric Supply (fully paid) xd	5½ 5⅝	5 5½	3 3 8	—	5⅞	5⅝
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/6	Brush Electrical Engineering	2⅞ 3⅛	3 3⅛	..	—	3⅛	2⅞
75,000	2	6%	Do. 6 per Cent. Preference	2 2¼	2 2¼	5 6 8	—	2¼	2⅛
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107 109	107 109	4 2 7	March & September	..	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Cumulative Pref.	4⅞ 5½	4⅞ 5½	6 1 9	January and July —	5	4⅞
12,139	5	..	Edison and Swan United	— —	— —	—	—	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	1⅜ 2⅛	.. ..	..	—	..	..
49,900	10	12/0	Electric Construction	1⅜ 2⅛	1½ 2	..	—	..	..
91,155	2	10/0	Elmore's Patent Copper Depositing	½ ⅝	½ ⅝	—	—	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	—	..	..
50,000	10	10,0	India Rubber, Gutta Percha &c., Works	21½ 22½	21½ 22½	5 11 1	February & August	..	..
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	2½ 3½	1½ 2½	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	4/0 5/0	4/0 5/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	2 2½	2 2½	14 11 6	May and November	2¼	..
37,350	12	12/0	Telegraph Construction and Maintenance xd	33 35	33 35	5 2 10	March and July	35	34½
£150,000	100	5%	Do. 5 per Cent. Bonds, red.1894	101 104	101 104	4 16 2	January and July —	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	—	—	—	—
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	—	—	—	—
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	8%	City and South London Railway	35 37	35 37	1 13 9	May and November	..	—
37,500	£10	£10	Liverpool Overhead Railway	4⅛ 4⅜	4⅜ 4⅝	—	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 795.—Vol. XXXI. FRIDAY, AUGUST 11, 1893. PRICE FOURPENCE. *Annual Subscription (U.K.), 19/6*

NOTES.

At the last meeting of the Glasgow Town Council it was cided by the by no means overwhelming majority of 27 to 21 adopt the recommendation of the Telephone Committee at a municipal telephone licence should be applied for. One ponent of the scheme characterised it as "rash and quixotic," d the data upon which the recommendation was based as crude and problematical," and the answer was that an appli- tion for a licence committed the Town Council to nothing particular, and that the only way to meet the National lephone Company in regard to the protection clause it had cceeded in getting inserted in the Tramway Bill was to ke the step recommended. Of course, if the municipal tele- one licence is to be used merely as a means of securing the peal of that clause the argument is good enough. On the her hand, if the Corporation mean business, reliable estimates om a competent expert, a promise of active adhesion on the rt of the National Company's present subscribers, and careful consideration of the attitude to be assumed in view of rate-cutting policy being adopted by the Company should ccede, not follow, an application for a licence.

The merits of a new process are sifted the more in pro- rtion to the catholicity, so to speak, of the criticisms which calls forth. When an inventor proposes a new mode of otive power for electrical supply he runs across fire from engi- ers of every interest. He is assailed on one hand by the lvocates of existing modes of motive power—the steam, the s and the oil engineers. He is assailed on the other hand by e advocates of systems of lighting and power distribution hich are not electrical. So has it been, to particularise, with e inventors of, and those interested in, the various forms of ater-gas, such an one for instance as Dowson gas. The e of this well-known gaseous fuel has been subjected to ch universal criticism that electrical engineers may con- atulate themselves on ultimately getting at its real value. he latest to enter—perhaps we should say re-enter— e lists is Mr. Denny Lane, who has a twofold interest the prosperity of the coal gas industry since he would mbine with gas lighting electric lighting by means of s engines, and who is, on that account a "foremost eman" worthy of Mr. Dowson's steel. To the use of the -called "producer" gas Mr. Lane opposes no less than eleven objections, some of which, at any rate, are of no little importance. The very much lower thermal value of a nitrogen-diluted water gas, compared with coal gas, would necessitate, according to Mr. Lane's calculations, mains having six times the section, gas-holders having four times the capacity, and a very much larger engine, in order to arrive at the same amount of distributed power. These are a very serious set off to the high fuel economy of the water gas system; and they raise points which no engineer, whose business it may be to select a system of power distribution can afford to overlook. But all this is rather beside the mark; beside Mr. Dowson's mark, if we properly understand it. In his valuable paper read before the Institution of Civil Engineers last session he said nothing about distributing his gas by mains, and is, no doubt, ready to admit most of the so-called "objections." The fact remains that Mr. Dowson claims that he can run a 100 H.P. electric light plant at a less cost than anyone else. He has challenged the world to compete with him, no one has responded, and like a champion athlete "against time" he is going to carry out the trial, and demonstrate at his own expense the validity of his claims.

We can only characterise as bold the scheme of power transmission in Switzerland, of which we give an account this week. There is nothing unusual or exceptionally difficult, of course, in the transmission through aerial conductors of about 400 H.P. over a distance of some 20 miles. Neither is there, we think, any very great advance made in the getting of 78 per cent. over all efficiency under these conditions. But the boldness of the scheme enters into the details in which it is worked out; into the system adopted, and the types of machines chosen. The desirability of transmitting the power at as high a pressure as possible need not be referred to; but the desirability of selecting Gramme-wound armatures coupled in series with a total pressure of 6,600 volts is not one which would be likely to strike every engineer at first or even at second thought. We understand that these same closed-coil armatures were run for some time as a test, delivering 10 amperes at 4,700 volts per machine. Whether or no it was the intention of the engineer, M. Goichot, to run the plant permanently at this voltage, we cannot say; but we can well understand the advisability of adopting the but slightly less risky voltage which is now in use. It will be interesting to see how the surfaces of the large commutators are found to wear, and to know whether any serious difficulties arise owing to sparking and flashing over.

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THE substitution of electricity for horses on the tramways of Brooklyn and other American towns is, as might have been anticipated, telling upon the number of tram horses employed. What the effect of the continuation of this elimination will be upon the genus *equus vulgaris* it is not the immediate concern of the electrical engineer to inquire. The domestic horse has been threatened with extinction more than once before, but will, no doubt, still find his place in the economy of civilisation. On the other hand, the effect of this substitution upon the comfort of the community is one to which electricians have every interest in inviting attention. One of the most abominable nuisances of our streets in summer is the dust, and in the winter the mud. Water added to the one makes the other; so we have only to discover the source of dust to find the origin of both these evils. Without doubt, nearly the whole of street dust is directly due to the presence of the domestic horse; for what his fodder does not produce is caused by the tramping of his feet on the road material. A careful examination of a sample of road dust collected on an asphalte road will be found to be almost wholly composed of particles of hay and horse food; on a wood-paved road it consists partly of splints of timber detached by the horses' hoofs; while on the less common macadamised road there is, of course, a considerable percentage of mineral matter. In fact, in whatever proportion the domestic horse becomes eliminated by the electromotor, it will be found that the city dust and the greater part of the street noise, will in the same proportion disappear.

THE wily ancient Egyptian priests who designed automatic machines for dispensing holy waters to those who were about to enter the temples of Osiris, Isis, or Horus, set a fashion which—long buried—has in these modern times been revived, and is now actually being applied to the dispensation of artificial light. The "penny-in-the-slot" meter has not, as yet, fastened itself upon electric mains; though it is already in use in a few railway carriages, and we believe to a limited extent for doling out coal gas. Possibly, by the adoption of this method, electrical engineers may solve the difficulty of differential charges; a meter being designed which with one mite at noon or two mites at night would pass a joule and a decimal through the circuit. What is really wanted, however, is a contingent of MAXWELL'S "sorting demons," who, stationed inside the meters, would tilt over the levers to the higher tariff at sunset.

Electrical Bills in Parliament.—The Hampstead, St. Pancras, and Charing-cross Railway Bill was read a third time in the House of Lords last week, and passed.

Cable Interruptions and Repairs.—

	Interrupted.	Repaired.
Paramaribo—Cayenne	April 15th	August 7th.
Aden—Zanzibar	August 9th	—

Southport.—At a special meeting of the Town Council last week it was resolved that a high-pressure alternating system of electrical supply should be laid down for the central area of the town, at an estimated cost of £13,000.

Bolton.—On Thursday last week Major-General Crozier, one of the inspectors of the Local Government Board, held an inquiry into the application of the Corporation for sanction to borrow £75,000, of which £40,000 was for the purpose of electric lighting.

Aberdeen.—There were 65 applicants for the appointment of Electrical Engineer to the Aberdeen Town Council, and Mr. E. T. Ruthven Murray, electrical engineer of Larne, County Antrim, has been appointed. The salary of the appointment is £250 a year.

The Trans-African Telegraph.—According to the Cape Town correspondent of *The Times*, the contractors are starting out to begin the construction of the first section of the Salisbury-Tete overland telegraph. Contracts reaching to the Nyassa have already been signed.

European Electric Traction Development.—The extent of European electric railway work, says the *Electrical Engineer* of New York, may be best expressed by referring to the fact that Boston alone has a greater electric railway equipment both in miles of road and number of cars than the whole of Europe.

Telephone Poles at Chesterfield.—At the last meeting of the Town Council, Ald. Wood moved that notice be given the National Telephone Company to remove all their poles now standing in the streets and thoroughfares, and that the Corporation require the wires to be laid underground. The resolution was carried.

A Wiremen's Strike.—The strike of the bricklayers and electric wiremen who were at work on the annex to the Mutual Life Building on Liberty-street, near Nassau-street, still continues, says the *Electrical Engineer* of New York. Forty-eight bricklayers, and eight electric-wiremen have been out, both sides contending that they are entitled to the work of making holes in the walls for the wires.

Cooling Bearings.—As a means of cooling bearings, an American suggestion is that in any place where air-compressors are used, or where an air supply is convenient, it would be well to conduct a pipe so as to blow air upon the heated bearings. Air has an additional advantage in the fact that it cools in expanding so as to still further aid in the cooling of boxes where this scheme is applied.

The Forthcoming Meeting of the British Association at Nottingham.—The Presidents of Sections A and G of the British Association this year will be Mr. R. T. Glazebrook and Mr. Jeremiah Head respectively. In Section A it is possible that the following matters will be discussed:—The establishment of a national physical laboratory, the publication of physical papers, magnetic and other units, the mechanical connection between ether and matter.

The Hobart-Town Electric Tramway.—A definite stage has been reached in the construction of the electric railway at this town. Recently the machinery at the generating station was put on a trial run. There are three Siemens-Willans steam dynamos, running at 350 revolutions, and having an output of 125 kilowatts. The boilers are designed for 60 H.P. at 160lb. pressure, and are of the Marshall multitubular type; there are four of these boilers, which are fed hot from two Marshall's feed heaters, by means of Worthington pumps. The overhead trolly system is to be used, each car being provided with two 15 H.P. Siemens electromotors.

The Use of Telephone Trunk Wires.—In the House of Commons last week Captain Bagot asked the Postmaster-General whether, in case the Post Office purchased from the National Telephone Company their trunk lines as contemplated, he would provide that all telephone exchanges having the use of such trunk lines in connection with their own exchanges should give facilities to other exchanges, irrespective of their ownership, for communication with their subscribers through such trunk lines. The Postmaster-General replied that the subject had been carefully considered, and the agreement now in course of negotiation provided for such facilities.

The Strand Lighting.—At the meeting of the Strand District Board of Works, last week, it was stated in moving the adoption of the report of the Works Committee that the Committee had had before them a scheme for the electric lighting of the Strand by the Metropolitan Electric Light Company, who propose to substitute for the present 67 gas lamps, costing £473. 11s. 11d. per annum, 22 arc lamps at a yearly cost, including renewals of carbons, cleaning, and all

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attendance, of £1,195 per annum, on the understanding that half that number of lamps would be extinguished at midnight. The Committee could not advise the Board to adopt the electric lighting until it became much cheaper.

Stafford.—At the quarterly meeting of the Town Council held last week the Electric Lighting Committee recommended that the scheme proposed by Mr. Bell, gas engineer, and endorsed by Dr. John Hopkinson, should be carried out, and that application should be made to the Local Government Board for authority to borrow £20,000, of which £12,000 was to be spent at once. The proposed price is 7d. per unit, and the system recommended is the continuous-current, low-pressure one. After some discussion the report of the Committee was carried by twelve votes to eight. On the recommendation of the Gas Committee, it was resolved that sufficient land should be set apart at the gasworks for a site for the electricity supply station.

Cheltenham.—At the meeting of the Town Council, on Tuesday, Mr. George Norman (Chairman of the Electric Lighting Committee) brought up the Committee's report, which recommended the adoption of the high-pressure alternating-current system of electric lighting for the town, the supply to be undertaken by the Corporation, using the ash destructor site for the station. Mr. Norman explained that Mr. W. H. Preece had given the Committee the benefit of his advice. A suggestion was made that the vote on the subject should be postponed for a month, in view of the smallness of the attendance at the meeting. The suggestion was not acted upon, and the Committee's report and recommendation were adopted by ten votes to one.

Lightning.—During some manœuvres at Nevesinji, in Herzegovina, last week, a group of Austrian officers was struck by lightning, one being killed and five injured. During the thunderstorm of Wednesday night considerable damage was done to life and property in various parts of the United Kingdom. Mr. Owen's flax mill at Ballymarlow, near Ballymena, Co. Antrim, was fired by lightning, and part of the premises was destroyed, together with a quantity of stored flax. In Wales Mr. S. J. Griffith Morswyn, a well-known Welsh poet, was returning to his home in the suburbs of Holyhead, when, as is supposed, he was struck by lightning. This morning he was found stretched on the ground in an unconscious condition, and died without having regained consciousness.

The Telephone in Denmark.—The Copenhagen Telephone Company will, says our correspondent, remove in about a year's time to a new central exchange which is being specially built for it, and which will be exceptionally well appointed in every respect with accommodation for 10,000 subscribers. The new exchange will be lighted by arc lamps and bids fair to be one of the best in existence. The multiple boards will be of a new and improved construction. In the meantime it has been necessary to extend the existing exchange, where the daily number of conversations is about 30,000. Experimental telephonic connection has recently been established across the Great Belt, a distance of some 20 miles, an existing submarine cable being used. The result was quite satisfactory, and the two islands of Zealand and Fünen will no doubt soon be in telephonic connection.

The Proposed Pacific Cable.—According to the daily papers Mr. Patterson, the Victorian Premier, has addressed a protest to the Governments of Queensland and New South Wales against their committal to a cable to New Caledonia, thus hindering the project for a British cable to Vancouver by any other route. Mr. Patterson protested against being compelled to accept the New Caledonian route without consultation, and said he should be glad to learn that Queensland and New South Wales were still free to contract for a main Pacific cable otherwise than *viâ* New Caledonia. No reply has been received to these representations, but Mr. Patterson has written to the Imperial and Canadian Governments disclaiming responsibility for the selection of the New Caledonian route, and both the New Zealand and Tasmanian Governments have expressed agreement with the position he has assumed.

Australian Mica.—At one time, says *Industries and Iron*, great hopes were centred upon the mica industry at the McDonnell Ranges, South Australia. Unfortunately, what promised to be a profitable industry languished through the fall in the price of mica and the difficulty of transportation to foreign countries. A large proportion of the consignments to Adelaide broke into small pieces on being trimmed, and these fragments were believed to be worthless. It is now, however, thought that they will command ready sale. In consequence, fresh parties are starting from Adelaide for the McDonnell Ranges to re-open workings which had been abandoned. The mica has to be carried some 500 miles on camels to Oodnadatta Station, the present terminal point of the great overland railway being constructed by the South Australian Government. Thence it is carried by train to Port Augusta and shipped to the most profitable of the world's markets. The great want on the field is a man who is accustomed to practical working of such deposits. At present an expert judge of mica is at McDonnell Ranges, and is purchasing mica there at rates very profitable to the miners.

The City and South London and Liverpool Overhead Railways.—The following comparative figures with regard to the City and South London and Liverpool Overhead railways may be of interest. It is to be observed, however, in connection with the locomotive and generating expenses per train mile that whilst on the London line the trains consist of three cars and a locomotive, at Liverpool each train consists of only two motor-cars; at Liverpool, moreover, the trains are run under a contract with the Electric Construction Company. The figures for total capital expenditure, capital expenditure per mile of line open, and passengers carried, are given in round numbers:—

—	City and South London Railway.	Liverpool Overhead Railway.
Length of line open	3½ miles	5½ miles
Total capital expended on line open	£873,000	£528,000
Capital expenditure per mile of line open	£280,000	£103,000
Present rate of passenger traffic per annum	6¼ million	4⅓ million
"Loco" and generating expenses per train mile	6·48d.	4d.
Passenger earnings per train mile run	24·7d.	26·6d.

Provisional Orders Granted.—In the last report presented to Parliament by the Board of Trade it is stated that 18 applications for Electric Lighting Provisional Orders were received in time for consideration during the current Parliamentary Session, 11 of these being made by local authorities. The following is a list of the Orders actually granted in the provinces.

Altrincham	Manchester Edison-Swan Company.
Barnet	Local Board.
Beckenham	Local Board.
Bridgend	Local Board.
Colchester	Corporation.
Eccles	Corporation.
Newcastle-upon-Tyne	Newcastle-upon-Tyne Electric Supply Company.
Newmarket	British Electric Light Company.
Partick	Commissioners of Police.
Reading	Reading Electric Supply Company.
Taunton	Corporation.

In the metropolis Orders have been granted to the Vestries of Hammersmith, Hackney, Islington, and Poplar. Sanction has also been given to the transfer of municipal Orders to companies at Cambridge and at Hove. Including the Orders just granted, there are now no less than 170 in force, of which 112 belong to local authorities. Of the 69 Orders granted in 1883 only 7 remain in force in 1893; these relate to Bradford, Brighton, Bristol, Nelson, Richmond, St. Pancras, and Greenock, the first six being now worked by the local authorities.

Central Stations in France.—A recent number of *l'Industrie Electrique* gives a complete table of the French provincial central stations for electric supply, and a map showing their distribution. The total number of these stations is 255, of which 209 are on the continuous current system. One of the most notable features is the large proportion of stations in which water-power is either entirely or partially used for driving the dynamos. Out of the total of 255 stations entered in the table, there appear to be as many as 160

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employing hydraulic power. Most of these, however, are only small country-side stations of less than 100 H.P. The number of stations run by gas engines is also considerably in excess of those to be found in this country. There are 17 of these, of which only one or two exceed 100 H.P., and the majority are very small. Another notable feature is the latitude which is given to the term "central station"; for we find that the smallest of the French stations has only 5 H.P., and the average is only 120 H.P. This miniature station is at Darnetal, in the Department of Seine-Inférieure, and is driven by hydraulic power. The largest provincial station, one of 2,000 H.P., is at Toulon; and Rouen, with a station of 1,200 H.P., takes the second place. There are 68 stations in course of construction.

Artificial Draught.—Everyone familiar with the management of steam boilers is agreed that no artificial draught is in all respects so satisfactory as that produced by a good chimney. The chimney draught is always at hand and ready for its duty, and the fireman has simply to pull open the damper to bring it into operation. There is, says the *Engineering Record*, no machine connected with it to require attention, nothing to get out of order, and there are no running expenses required to maintain it. Although these things cannot be said of a draught which is produced by mechanical appliances, there are some features connected with artificial draught which commend it to the engineer and to those who have the care of a steam plant. We refer to the system embracing an exhausting fan placed in the smoke flue, which is operated by an independent engine. Looking at the subject from an engineer's point of view, the use of the mechanical draught enables the heat of the waste gases to be utilised without sacrificing the draught power. This advantage may assume great importance in obtaining economy in the consumption of fuel, for a reduction of every 15deg. to 20deg. in the temperature of the gases by the use of a feed-water heater in the flue secures a saving of 1 per cent. of fuel. Apart from this it must be agreed that the flexibility of a system of artificial draught is an advantage which under many circumstances which arise in the working of a plant of boilers has much to commend it. If for any reason an unusual force of draught is required to maintain the necessary supply of steam, the fireman simply gives the throttle valve of the fan engine an extra turn, increasing its speed and securing the desired increase.

Massachusetts Institute of Technology.—We have received a well-written and artistically illustrated pamphlet, prepared in connection with the Chicago Exhibition, giving a brief account of the foundation and character of the Massachusetts Institute of Technology. This is the largest scientific and technical school in the United States and one of the largest in the world. From a recent report it appears that during the last session no less than 1,060 students of both sexes took advantage of the courses of technical and scientific instruction, which were provided; the various classes being superintended by a staff of 125 teachers. There are 13 separate courses, each covering four years of lectures and laboratory instruction. The equipment for electrical engineering and allied studies is on a most magnificent scale, and includes three spacious and well-stocked laboratories, besides the lecture rooms and a set of technical libraries containing nearly 27,000 volumes. The allied sciences of chemistry, mathematics, and mechanical engineering appear to be equally well provided for; so that, with the proper amount of time at his disposal, the electrical student can either master completely the details of one special branch of his calling or he can attain great breadth of information by "all round" study. One of the avowed objects of the Institute is "to make the pupil observant, discriminating, and exact;" so that it aims at combining the mental education of the universities with the instruction of the technical institutions. Success in this direction is, it appears, possible without, on the one hand, the necessity for teaching so called "useless knowledge," or, on the other hand, adopting the practice of labelling a technical institute with the misleading and ambitious name of university.

The Telephone in Scandinavia.—The means of telephonic communication within and between the Scandinavian countries are, says our Copenhagen correspondent, being steadily and continuously extended. The necessary funds have now been voted both by Sweden and Norway for telephonic connection between the two countries, and the Stockholm-Christiania line will be forthwith taken in hand. The line will be 350 miles long, of which only 90 miles come in Norway and in Sweden. The existing telephone wires can be used for the greater portion of the Swedish section. In Norway 3·3 millimetre copper wire will be used, and the same poles will be used where possible, as are already used for the telegraphs, but to avoid induction the telephone wires will be twisted. In Sweden this line will be worked by the State; in Norway it has been left in the hands of the Christiania Telephone Company. The fee for a three minutes' conversation will be one shilling, eighteenpence, and two shillings, according to the distance included on the Swedish side of the frontier. Should the Stockholm-Christiania telephone line prove a success, a Christiania-Gothenburg line will probably, ere long, be taken in hand. The work in connection with the Swedish-Danish telephone, under the Sound, is also in full swing. The new line between Malmö and Hildesborg, on the Swedish coast, is about completed; and the Copenhagen-Vedbök line, on the Danish side is also in hand. There will be double wires on both sides. One of the existing submarine cables will be used. Conversations between Denmark and Sweden will be limited to three minutes, and the charge for a conversation with Malmö and surrounding district will be eighteenpence, which cannot be considered an excessive charge; for more distant parts of Sweden the charges will be higher. The Swedish State telephones are going ahead at a great rate, and in spite of the youth of this institution it has entirely put the State telegraphs in the shade as far as cost of installation goes. Another million of krone was not long ago placed at the disposal of the State telephones, which will be applied to the purchase of private telephone companies, and to the erection of a new central station at Gothenburg.

The Electrical Transmission of Power.—In the Foreign Abstracts published by the Institution of Civil Engineers there is a reprint of a Paper read by M. E Hartmann before the German Society of Engineers, in which details are given of the efficiency and working cost of power electrically transmitted to working machine tools, lifts, and cranes. When the works of the General Electrical Company, of Berlin, were designed, provision was made to distribute power through the various departments electrically. The system adopted consisted in grouping machine tools so as to receive power from short lengths of light main shaftings, each length of shaft being worked by an electromotor. In some special cases each machine was provided with its own motor. In all there are now some forty motors in use, with a total of 400 H.P., which is distributed by cables from a central station in the works. Experiments were made to ascertain the total efficiency of power transmission between the central steam engine and the various machine tools, the latter working under ordinary conditions; and it was found that about 64 per cent. of the power developed was actually delivered to the various machines. Herr Hartmann also made tests in another factory where long lines of heavy main-shafting transmitted about 250 H.P., and found that the efficiency under normal conditions of working was only 54 per cent. A further set of experiments concerned the efficiency of helical spur-gear (97 per cent.) and worm gear (84·6 per cent.). An example is given where the substitution of electricity for mechanical transmission resulted in considerable saving of power. This was a grist mill originally driven by shafting giving an efficiency of 51 per cent. After the introduction of the electric plant the efficiency rose to 74 per cent. The author next compares electric transmission with the employments of small steam engines, scattered about in various shops, and receiving steam through long steam pipes. He finds that under these circumstances not less than 48lb. of coal are consumed per horse-power hour, whereas with electric transmission the consumption is reduced to 24lb.; and he cites as an example the railway works in Görlitz, where 100 H.P. is so transmitted. He next considers the electric transmission of power to lifts and cranes, and compares it with pneumatic and hydraulic transmission, finding that in most cases the electrical system is more efficient.

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REVIEWS.

Electrical Papers. By OLIVER HEAVISIDE, F.R.S. 2 Vols., pp. 560 and 578. (London: Macmillan and Co.)

These volumes consist principally of reprints of Papers published in *The Electrician*, and in the *Philosophical Magazine*, and other papers at various dates since 1872 and up to 1892. In the Preface Mr. Heaviside ventures on a most unnecessary apology for publishing them. They are much too valuable scientifically, practically, and historically to be left buried discontinuously in a variety of serials. The Editors of *The Electrician* are to be most particularly commended for their public spirit in publishing such long series of Papers which can only have been interesting to a small minority of their readers, but which were so principally because the Papers were pioneers in the subject they treated of.

The Papers are valuable scientifically because they contain a consistent and sound method of attacking electromagnetic problems in consonance with, and in extension of, Maxwell's theory, and because they contain very valuable scientific results deduced by this method from this theory. The Papers are valuable practically because they teach a sound theory of telegraphs and telephones, and of other matters, such as induction balances, which has already resulted in Prof. S. P. Thompson's patent for increasing induction in telegraph wires, and which, there is every prospect, may lead to vast improvements in telegraphy and telephony, and may even make it possible to work a telephone across the Atlantic. The Papers are valuable historically as being a most interesting record of the development, methods, and scientific views of nature, in an extraordinarily acute and brilliant mind.

Many complain that Browning is unintelligible. Some say that he writes nonsense. His admirers worship him. Oliver Heaviside has the faults of extreme condensation of thought and a peculiar facility for coining technical terms and expressions that are extremely puzzling to a reader of his Papers. So much so, that there seems very little hope that he will ever attain the clarity of some writers, and write a work that will be easy to read. In his most deliberate attempts at being elementary, he jumps deep double fences and introduces short-cut expressions that are woeful stumbling-blocks to the slow-paced mind of the average man, when reasoning about concepts that he (the average man) is not very familiar with. Combined with this is a delightful freshness of illustration and brusqueness of expression that makes some parts of his Papers very lively reading indeed. For example, in connection with the nature of matter he says, "Even if we resolve all matter into one kind, that kind will need explaining. And so on, for ever and ever deeper down into the pit at whose bottom truth lies, without ever reaching it. For the pit is bottomless." These personal characteristics of style increase very much the historical value of this reprint. It is this historical value that compensates very largely for the considerable amount of repetition which makes the work longer than a connected new work on the subjects included in the Papers would be. The repetition is largely due to the way in which the Papers were published in various serials and in several series. In each, much preliminary ground had to be gone over in order to make the succeeding extensions intelligible to those who might not have seen the preceding series. Repetition in a minor degree arises from the development of method that was proceeding in the author's mind and that required former results to be reviewed in the light of improved methods and advanced results.

It will be convenient to divide the consideration of these Papers into remarks on the author's methods, on the theories he has developed, on the practical applications of these theories, and on the innumerable questions as to the nature of things which he raises.

The great advance in method that the author has made is due to his consistently following out the principles that Maxwell laid down in accordance with Faraday's ideas as to the nature of electromagnetic actions. Maxwell had clearly pointed out that the state of the ether at each point depended upon the electric and magnetic forces there, and upon the electric and magnetic diplacements they produced. Maxwell, like every other poineer who does not live to explore the country he opened out, had not had time to investigate the most direct means of access to the country nor the most systematic way of exploring it. This has been reserved for Oliver Heaviside to do. Maxwell's treatise is cumbered with the *débris* of his brilliant lines of assault, of his entrenched camps, of his battles. Oliver Heaviside has cleared these away, has opened up a direct route, has made a broad road, and has explored a considerable tract of country. The maze of symbols, electric and magnetic potential, vector potential, electric force, current, displacement, magnetic force and induction, have been practically reduced to two, electric and magnetic force. Other quantities it may be convenient, for the sake of calculation, to introduce, but they tell us but little of the mechanism of electromagnetism. The duality of electricity and magnetism was an old and familiar fact. The inverse square law applied to both, every problem in one had its counterpart in the other. Oliver Heaviside had extended this to the whole of electromagnetics. By the assumption of the possibility of magnetic conduction he has made all the equations symmetrical. Every mathematician can appreciate the value and beauty of this. Can anyone be sure that the ether does not ultimately yield to magnetic force? Can we be sure that there is absolutely nothing corresponding to that diffusion of strain that exists in almost every solid? Can we assert positively that there is no diffusion of motion, such as Lord Kelvin has pointed out interferes seriously with vortex hypotheses as to the structure of the ether?

In addition to this he has done his best to popularise vector analysis. For what, to those familiar with Hamilton's notation, seem very insufficient reasons, he has sacrificed a great deal of what was valuable in Hamilton's methods. In order to avoid a negative sign and the occasional use of S, he has given up the versor interpretation of his symbols. He was driven to this apparently by the semi-metaphysical foundation upon which Hamilton based his system, which, however, can be based upon a series of definitions just as easily as Mr. Heaviside's own system. That one who works with sin, cos, tan, cotan, sec, cosec, sin$h$, cos$h$, tan$h$, cotan$h$, sec$h$, cosec$h$, $I_0(ix)$'s, &c., &c., should be troubled by an S and a – sign seems too incredible for this latter reason to have really influenced him; but there is no difficulty in understanding how one who is so constantly requiring to see clearly how his symbols represent the facts should have been deterred by a semi-metaphysical basis from resting on another man's foundation, and should have invented a system for himself with a foundation that he clearly understood.

Running through a good deal of his work and coming to a definite suggestion in the last volume is the question of units of measurement. That eternal 4π troubled him as it has troubled everybody else. It is nearly true that the only rule for introducing it is to consider carefully whether it should be in or no, and having come to the conclusion that it should not be in, then immediately introduce it. It is to be regretted that we inherit the misfortunes of our ancestors, and that electrical and magnetic phenomena were known before electromagnetic ones, and that thus the 4π came in so unfortunately, but there is too much capital sunk in the present system for it to have any chance of changing. When people tolerate miles and furlongs and pecks and bushels and barrels and firkins and hogsheads, &c., &c., how can they be expected to get up any enthusiasm over the eviction of 4π?

In the theory of electromagnetic phenomena the author has made great advances. He has extended the theory of wave propagation in complicated media, of waves along wires and into them, and of the effect of the motion of the medium. The questions are too scientifically technical to enter into here, but it must not be concluded that because they are only shortly noticed that therefore they are unimportant. In fact the extension he has given to the theory of the propagation of waves outside and inside telegraph wires is the foundation for

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a large part of the most important practical applications of electromagnetic theory that he has pointed out.

The most important practical applications of his theory are to the use of induction balances and to the improvement of telegraph and telephone lines. In this latter field he is unique as an investigator, and everyone of his suggestions is worthy of the most serious consideration by those who desire to advance this application of electromagnetic energy. In this connection he has called particular attention to and worked out in a very complete manner the penetration of the current into the conducting wire, the effect of the self-induction in neutralising the evil effects of capacity, the effect of leakage in improving signals, and the conditions that the terminal receiving instruments must fulfil in order that they may not themselves introduce confusion. The effects of all of these, except leakage, are now quite familiar to users of alternating currents, thanks in no inconsiderable degree to Mr. Heaviside. Long before tube conductors were used on the Deptford installation this theory was worked out by him and equations given for calculating how thick the tubes should be which should have been usable by properly educated practical electrical engineers, or which should at least have shown them that Mr. Heaviside was the person whom they should consult upon such a point. Long before Mr. Ferranti observed a, to him, new rise of voltage in London, Mr. Heaviside had called attention to the same thing in connection with telegraph signals, and had shown to what it was due and on what principles it could be avoided, by the use of carefully designed receiving instruments. Long before practical engineers were at all familiar with the way in which capacity and self-induction produce opposite effects upon the difference of phase between volts and amperes, Mr. Heaviside had shown how to use this in designing telegraph cables in which some of the evil effects of capacity could be to a large extent neutralised by increasing the self-induction. Before Prof. S. P. Thompson took out patents for increasing this self-induction, Mr. Heaviside had suggested and had proved the efficiency of putting iron filings into the insulation of a cable, had suggested drawing a double wire of iron and copper, and had shown that by winding iron wire like gimp outside the copper wire a continuous self-induction might be obtained which would improve the efficiency of telegraph and telephone lines. Everyone is familiar with the way in which self-induction alters the impedance more and more the greater the frequency. What Mr. Heaviside has shown is that by a proper combination of self-induction and capacity the effects on waves of small frequency can be made nearly the same as on those of large frequency, and that consequently speech, which consists of a mixture of waves of all sorts of frequencies, can be much better transmitted than by a line in which either capacity or self-induction preponderates. He has further shown that by a proper regulation of leakage it is possible to still further improve articulation. Telephony, in accordance with Mr. Heaviside's predictions, has advanced so much of recent years beyond what was a few years ago regarded as its limits, that it confessedly requires an amended theory. When the properties of a line have to be determined experimentally after it has been laid down, it is confessed that the theory of those who are unable to predict its behaviour is incomplete. Mr. Heaviside is, by the practically unanimous opinion of scientific experts, and by his success as a prophet, pointed out as the authority from whom this amended theory comes, and who should be consulted by all those who desire to improve telegraphic signalling. He is a scientific expert of the best kind in these subjects, and it is very much to be regretted that scientific experts are, in these countries, so highly paid to advance causes and so very seldom paid to advance practice. The telegraph department has, however, shown itself anxious to improve the means of communication by applications of the most recent scientific ideas, and it is inconceivable that any personal friction should really stand in the way of the utilisation of what the Royal Society has crowned with a Fellowship.

The questions of scientific and practical interest raised by Mr. Heaviside are innumerable and most suggestive, as might be surmised from the acute and ingenious nature of his intellect. He has traversed the Von Helmholtz theory of a double electrical layer at the contact of dissimilar bodies, and Clausin's theory as to the Thomson effect being due to change of structure. This latter is largely a question of words and of the meaning of the term "change of structure," and the author's theory as to the former is surrounded by serious difficulties, as, indeed, is every theory as to the connection of matter and electricity. There are discussions as to the internal energy of a magnet which are interesting in connection with the puzzle as to why the self-induction of a circuit is independent of the magnetic field. He raises questions as to the equilibrium of the ether when transmitting radiations owing to the pressure exerted by alternating currents upon conductors, as to the flow of energy through the ether, as to magnetic storms and earth currents being connected with solar waves, as to the rate of subsidence of earth currents, as to the behaviour of metals to light, as to the nature of lightning flashes, as to the effect of the motion of matter through the ether, as to the inertia of electric currents, and as to many other matters. As regards solar waves causing earth currents, Lord Kelvin has pointed out a serious difficulty in the enormous amount of energy that such a radiation would require, from which it would seem that if magnetic storms are due to solar causes they must be connected either very indirectly with solar magnetic storms, or else that the electromagnetic influence is confined to some ray projected from the sun, and which happens to cross the earth; though, here again, it is difficult to see how such a ray can be produced unless it is a projection of electrical ions in some of the outlying streamers of the corona. In connection with this matter of electromagnetic waves, it is interesting to observe that any moving body magnetised like the earth is continually emitting waves and losing some energy, though, in the case of the earth, an almost infinitesimal quantity. It would be interest to consider the problem of the motion of two oppositely electrified bodies round one another. The question would be complicated by the finite rate of propagation of the influence between them, and by the loss of their energy by radiation. In view of the Maxwell light pressure, would moment of momentum be conserved? or would the problem be practically the earth-moon problem with tides absorbing energy? How would the aberration of the force due to the velocity of the bodies and of the force affect the problem? In connection with the question of the inertia of electric currents we owe it principally to Mr. Heaviside that he has put away the temporary function that Maxwell introduced as the inertia of the current, and has concentrated attention on the magnetic force as the true source of what is analogous to inertia in electromagnetic questions. In view of the duplex nature of electromagnetic phenomena, which Mr. Heaviside more than anybody else has taught us to recognise, it is a little startling to find him stating so very confidently that electric current has *no* inertia, while it would appear from this very duplex property that we might *à priori* have attributed *all* the inertia to the electric force and none to the magnetic, just as satisfactorily as the reverse. It is evident, however, that we must know more about the structure of the ether, and possibly of its connection with matter before we can finally decide what is the really soundest view of the matter, and that no finally satisfactory answer will be given until all energy has been explained as kinetic energy.

Since Oliver Heaviside has written, the whole subject of electromagnetism has been remodelled by his work. No future introduction to the subject will be at all final that does not attack the problem from at least a somewhat similar standpoint to the one he puts forward. It is to be hoped that some author with a genius for popular exposition will soon write a "New Electromagnetism" with action at a distance strictly tabooed. With electric pressure and the displacement it produces as the source of the electric energy per unit volume in the ether, and with magnetic momentum and its accompanying flow as the source of the magnetic energy per unit volume in the ether, with these as the leading ideas of the work. Such a work would be electromagnetism up to date, and its possibility would be largely due to Oliver Heaviside.

GEO. FRAS. FITZGERALD.

Trinity College, Dublin.

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POSSIBLE AND IMPOSSIBLE ECONOMIES IN THE UTILISATION OF ENERGY.*

BY PROF. ALEX. B. W. KENNEDY.

(*Continued from page 365.*)

It is certain that no steam engine in existence works in a ycle which would give out—even if the cycle were perfectly ırried out—this efficiency. But it is also certain that we can- ɔt, by any changes or inventions whatever, make any engine ork in a cycle which shall have a higher efficiency. So, for ıch general purposes as the present, it is quite sufficient to ok upon it as a maximum value, and a limiting value, and limiting value which falls tolerably short of unity.

I am, not, of course, able here to give you my authority, or) reason out the statements I have just been making. I ust only ask you to accept my statement that in attempting transform heat energy into mechanical energy in any ıysically conceivable steam engine, we start with an absolute ıpossibility of getting more than 30 per cent., or so, of the

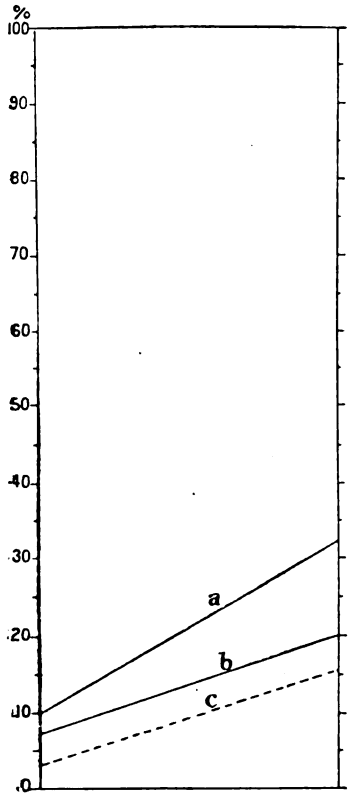

Fig. 4.

ɔrmer to appear as the latter. That is to say, our richest con- eivable ore might contain 30 per cent. of metal. What we ıave actually to do, however, is to work with far purer ores han this. In any actually possible steam engine the process liffers so much from the ideal that not more than 20 or 25 ɔer cent. could be attained even if the process were carried ɔut perfectly. But there are very great difficulties in the way ɔf carrying out even this imperfect process at all completely, ınd so it comes about that, in the final results, only from 5 to ɔerhaps 15 per cent. of the whole heat of the steam is ever urned into work, sometimes a little more, more often a little ess.

Ninety per cent. of energy wasted, to say nothing of 95 per ent., seems to leave a glorious field for improvement. It ooks so much as if, somehow, we ought to be able to do ten imes, or twenty times, as well as we are doing, with such a remendous margin of possibilities.

I may illustrate the real state of the case by Figs. 4 and 5. In Fig. 4 100 per cent. is taken as representing the whole heat of the steam. The area under the line *a* represents the proportion of this which might actually be turned into work with an ideally perfect engine, working in an ideally perfect cycle. The area under *b* represents the amount which might be turned into work by an ideally perfect engine, working in its actual cycle. Lastly, the area under *c* represents the total amount of energy which actual engines do turn into work. In each case the left-hand side of the diagram represents a poor machine, and the right-hand side a good one. In Fig. 5 I have taken the ordinates of the line *a*, as representing 100 per cent., and drawn the other two below them in their proper relative places. This is equivalent to saying that we cannot increase the richness of the ore, and that we give up any attempt to utilise the large spaces shown above *a* in Fig. 4, for the simple reason that it is impossible to do so. Fig. 5 therefore shows what really is possible. It will be seen that the margin is large enough, but the possibility is only of doing twice, and not ten times, as well as at present. It is sad to think how much time and thought has been spent in kicking against brick walls in this matter. Nature, however, is inexorable, and will not allow us to pretend that larger savings are possible than she

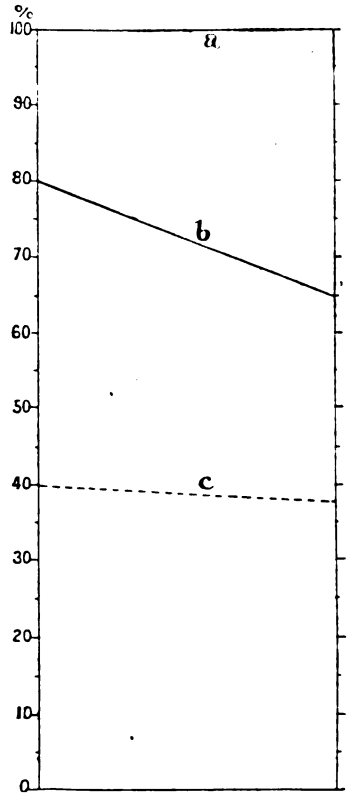

Fig. 5.

will allow us. But while I put things strongly in this way, do not let me be supposed to suggest that nothing can be done to diminish the huge proportion of waste energy indicated by Fig. 5.

Looking back again at Fig. 3, what possibilities are there of increasing the theoretical maximum efficiency of an engine? The whole matter depends upon whether we can increase the value of the fraction $\frac{T_1 - T_2}{T_1}$; practically that is all. We can do this obviously by either making T_1 higher or T_2 lower, or both, but without doing one or the other I will ask you clearly to remember that the huge waste area in Fig. 4 is absolutely inaccessible to us. It is not difficult to see how this matter comes out practically. In all heat engines some fluid or other is used as a vehicle for the transformation of heat into work. It may be coal gas or producer gas, steam, air alone, or air mixed with the products of combustion, or even ether or ammonia. With steam we work between the temperatures of, say, 60° or 400° F., or thereabouts. Quite at the other end of the scale come engines worked by gas of different kinds, where

* Lecture given at the Royal Institution, April 21, 1893.

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combustion actually take place inside the engine and not in a furnace, and where the highest temperature may, perhaps, be as great as 2,000° F. Hot air occupies an intermediate position with ether or ammonia; the temperatures are all very much similar. From our present point of view it is necessary to remember that all these divers working fluids work under the same physical laws and limitations. There is no dodging of thermodynamic principles possible. Nature, in fact, cannot be persuaded, even by the most seductively worded prospectus, to make exceptions in favour of particular materials. How, then, do these various working fluids stand in reference to this problem of economy?

First of all, the mere nature of no one gives it any advantage whatever. The fact that steam can be liquefied in a condenser is a great convenience to us, but does not make it, *per se*, one whit worse or better than air, which cannot be liquefied, at least in a condenser. The manner in which the choice of fluid affects the value of the maximum possible thermo-dynamic efficiency is indicated in Fig. 6, which may be taken really as a diagram—to use our former illustration—of the richness of ores. With gas, the highest temperature is the temperature of combustion; the theoretical maximum efficiency is so very high that we might look upon the gas as being almost a nugget. With air, the temperature is only indirectly

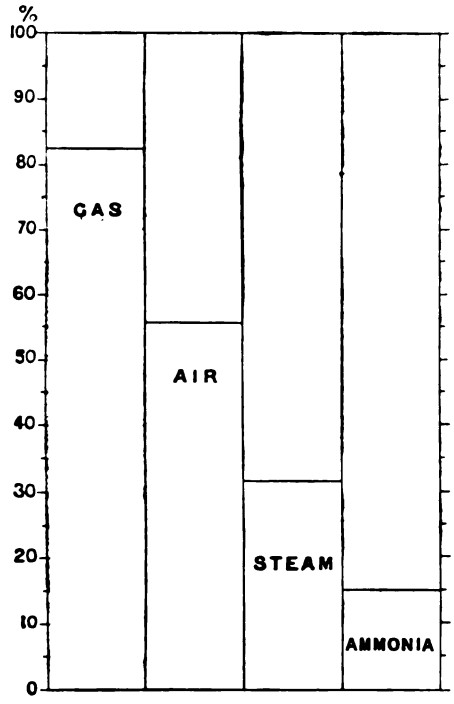

FIG. 6

derived from the temperature of combustion, and the maximum efficiency is smaller, although it is still high. With steam (apart from super-heating) the temperature is dependent upon, and limited by, considerations of pressure, and consequently of safety. With ammonia it is similarly limited; but the engine lies much further down the scale, both as to T_1 and as to T_2.

From Fig. 6 we may gather that with gas engines the theoretical efficiency is already so high that we need hardly trouble ourselves about attempting to raise it. With gas, in fact, and to a smaller extent with air, the possibility of improvement lies in bringing the actual up to the theoretical process, and not in attempting to raise the efficiency of the latter; that is to say, we must with them leave the losses represented by Fig. 4 alone, and try to deal only with those shown in Fig. 5. With steam, however, it is different. We want much to raise the theoretical limit of efficiency. But here we are dealing with a material which is liquid at ordinary temperatures and pressures, so that in its working condition it is a vapour and not a gas, and its temperature cannot be raised without at the same time raising its pressure. Considerations of safety and strength of our materials become here very important, but even if we left them out of account altogether, and raised the value of the maximum working pressure of steam engines from its present limit of 10 atmospheres to 20 atmospheres—that is, 100 per cent.—we should have increased the theoretical maximum efficiency only about 10 per cent., a quantity hardly worth considering in such a case. Clearly this is not a very promising direction in which to work.

No doubt the direction in which to seek for improvement is in that of what is called super-heating the steam, or raising its temperature after it has been formed—converting the vapour into gas without increasing its pressure. Theoretically this can be done to any extent, and I have no doubt that within the next coming years it will be very largely done. It is no new idea, although it is only recently that the use of mineral lubricants in engines has made it thoroughly practicable. As an illustration of its great benefit, I may mention that I found, some two years ago, that a little ordinary 4 H.P. engine, one cylinder, late cut off, moderate pressure, worked by a Serpollet boiler in which the steam was super-heated 200°F., gave results positively much better than I obtained not long after from a fine 100 H.P. Corliss engine, made by one of the best firms in Lancashire, and used in the ordinary fashion, with the same steam pressure but no super-heating.

Under ordinary circumstances I should have expected the little engine to use at least four times as much steam per horse-power hour as the large one.

At one time, when high-pressures were looked at askance and high-temperatures were thought almost as impossible, great hopes were entertained of increasing efficiency rather at the bottom than at the top end of the temperature scale. It was proposed to use an auxiliary engine working with ether or anhydrous ammonia, or any other substance whose boiling point might be made as low as the temperature in the condenser of the steam engine. But there are such great practical objections to this plan that it has at present disappeared from the range of practical engineering. Undoubtedly, the most promising direction for improvement is to go up, and not down the temperature scale, and he will be a great benefactor to us all who will devise a good and not too bulky super-heater applicable readily to existing work.

All this is rather in the direction of potential than of actual improvement, viz., improvement in Fig. 4 rather than in Fig. 5. In the latter, however, there are still large possibilities, as the Figure shows. The losses here are due to many causes, but chiefly to two. The first of these is that the steam is thrown away at too high a pressure, *i.e.*, that it is not expanded sufficiently far in the cylinder. Mechanically this is remediable at once, but only at the cost of making the engine unduly large and costly for its work. This cause of loss is, therefore, likely to remain. The second is one about which there has been much controversy both here and abroad, but which, thanks to the work of such men as Willans and Cotterill and Donkin, is now much cleared up. It is simply this—that as the fresh hot steam is always admitted to a cylinder which has just been emptied of steam having a much lower temperature, a cylinder, moreover, which is made of excellently conducting material, a very large proportion of that steam is at once converted into water on entrance, so that for every cubic foot of steam which leaves the boiler and passes along the pipes perhaps only two-thirds, or even half or less, does work in the cylinder as steam; the rest passes through the engine as water, or is sometimes partially re-evaporated, but never in such fashion or at such time as to be of much real service in doing work. There are thousands of engines at work to-day in which for every ton of water which has been evaporated in the boiler half a ton does no good whatever, except to warm up (by being condensed itself) the engine sufficiently to allow the other half ton to do work.

Here truly is a field for economy, and one with very great possibilities. I do not speak here of steam jacketing and other methods in partial mitigation of the waste, for these could hardly be discussed except in a very technical fashion. I will only say that there is no doubt that the great benefits which have been derived from super-heating, and the still greater possibilities of economy which exist in it and will probably soon be more heard of, are not at all only connected

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with the rise of maximum theoretical efficiency. The drying of the steam very largely influences its behaviour under the conditions I have mentioned, and unquestionably helps enormously to diminish the waste area in both Figs. 3 and 4.

I have talked long about steam engines. The subject is tempting, at least tempting to me, and, after all, steam is still the working fluid *par excellence*. But I must not forget that my subject has many branches, and must look at some of the others.

I say nothing about hydraulic motors, as the subject is one in which I have practically done no work, and I do not wish to give you second-hand figures.

The future of gas engines is one which has great possibilities; we have seen that they represent, in fact, the richest ores which we have yet discovered. Up to a certain point their progress was astonishingly rapid; at present, for a few years, it has more or less stood still, although the number of them has continually multiplied. Just now there are signs that the manufacturers—just possibly it may have something to do with the pressure of severe competition—are going to do their best to move forward a little, to make larger and faster running machines, and, in fact, to make an effort to penetrate further into the country where the steam engine has for so long held undisputed sway. About this we must not concern ourselves here, however. In Figs. 7 and 8 I have put down in a diagram the present state of gas-engine working, so far as I have been able to analyse the results of some of my own experiments. These figures are arranged to correspond with Figs. 4 and 5 for steam engines. In Fig. 7 the maximum theoretical efficiency is seen to lie about 80 per cent., as represented by the line *a*, the heat actually turned into work is represented by *b*. It is obvious that our theoretical maximum efficiency is so high that we need hardly attempt to raise it, especially as we are so far from actually realising it as yet. In Fig. 8 the theoretical maximum efficiency is taken as 100 per cent., and the line *b* shows how much of this is actually turned into work, the area above *b* representing the lost energy. The greatest cause of loss, that above the line *c*, is represented by the heat taken from the water surrounding the cylinder. The fact is we are trying to obtain incompatible results. To reach the high efficiency we make the initial temperature very high.

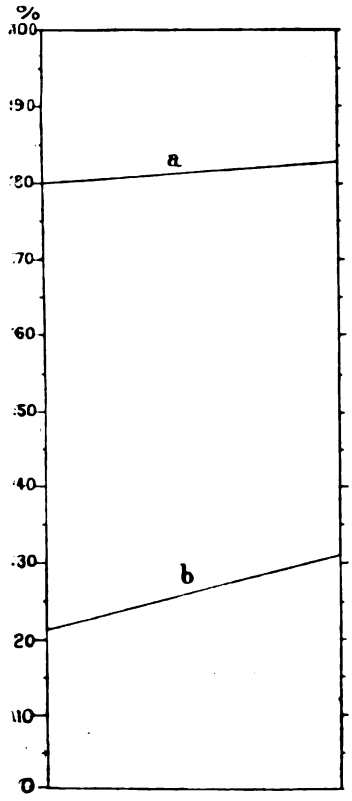

Fig. 7.

But, then, any such temperature would melt up our machines altogether, and leave it as flat as Ice Peter in the picture book after he had been put against the stove, if the metal were only allowed to reach it. We have, therefore, to adopt the somewhat barbarous expedient of continually keeping the metal cool by a current of water passing through a jacket. This water must of necessity pick up all the heat which can get through the metal and carry it away to waste. The result is obvious in the figures. Although, therefore, our theoretical maximum efficiency is so much greater than that of a steam engine (comparing the lines *a* in Figs. 4 and 7), our actual efficiency is not nearly so great (comparing the lines *b* in Figs. 5 and 8). Notwithstanding this, the actual energy utilised per thermal unit of combustion heat in a gas engine is very considerably greater than in a steam engine.

Undoubtedly, very great possibilities for increased economies exist here. The appearance of a new type of gas engine which should use only half the gas per horse-power hour which present engines used, would doubtless be received with scepticism, but with all that one could not say for certain beforehand that it was an absolute fraud, and I am quite prepared to hope that it may make its first appearance presently. But it is not at all so easy as in the case of a steam engine to suggest the direction in which to work for increased economy. Paradoxical as it may seem, it is not improbable that a *reduction* of the initial temperature might in this case be attended with economy; there is no doubt some one temperature at which the loss and gain just mentioned would adjust themselves most advantageously. A solution of the whole matter—a solution which would also greatly help the steam engine problem—would be the discovery of some non-conducting material which was at the same time suitable for use in the construction of engines. Chemists have done much for us, but we still wait for our non-conductor! Something as strong as iron and as easily machined, with the conductivity of sawdust, is what we want, a material which at the same time must remain sensibly unaffected by excessively high temperatures and which will stand rubbing to any extent. Perhaps the coming man, who is to produce this stuff, is here to-night. If so, I congratulate him on his future.

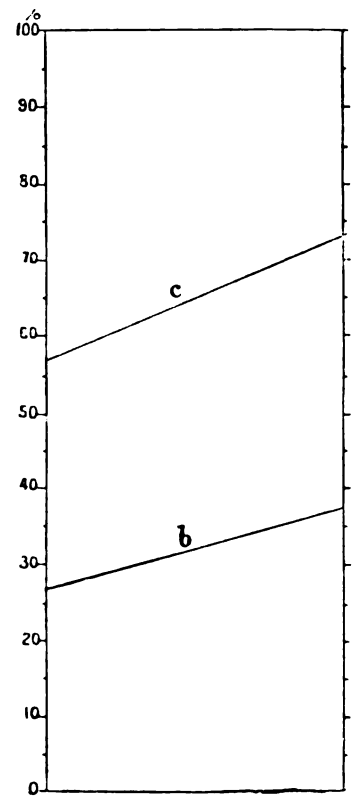

Fig. 8.

(To be continued.)

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1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.

Telephone No. 2714. *Telegrams :* "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed "Coutts and Co."*

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LOGIC AND ENGINEERING.

Of all the exact sciences, formal logic is the one which receives from practical engineers an amount of attention which is least in proportion to its intrinsic merit. Yet it is one, of which it is only necessary to state its scope and meaning, in order to completely demonstrate it great importance, alike to the practical man as to the theorist. The science of exact reason is, in fact, the essence of all the reason in exact science; and, apart from it, there can be neither reliable practice nor accurate theory. Whether, on its deductive side, the inferences from established principles in science have to be drawn in relation to some special problem; or whether, on its inductive side, it is necessary to arrive at the generalised truth which underlies and co-ordinates any given set of special facts, the processes by which science, and engineering science in particular, must extend into new fields or strengthen its hold on fields already taken, are founded strictly upon the abstract laws of logical thought. Whether, for example, the theorist seeks to find out the essential principle which underlies the known series of electromagnetic and optical phenomena, and thus to arrive at—inductively—some exact knowledge of the ether; or whether the practical engineer wishes to locate a "fault" in his system of cables, or "knocking" in his steam-engine; it must ever be by a more or less exact, or more or less crude and unconscious, application of logic. This being the case, it would seem that very little argument ought to be necessary in order to establish the science of exact reason as a regular branch of scientific training. Unfortunately, however, there are so many specious objections raised against this practice that it will require a much

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more vigorous effort in favour of logic before it is likely to be accepted very generally.

One of the most common objections is, that formal logic is unnecessary as a *separate* training, since it is implied in all the other exact sciences which are taught; that in other words, mathematics, theoretical physics, chemistry and mechanics, and the free use of laboratories, are enough to render a student logical. To such objection there may be granted this much; that the systematic and proper study of the sciences named does, in time, induce a logical form of mind, and trains the student's mind to run in proper grooves instead of flitting about like a butterfly. But the result is by no means as rapid or as satisfactory as would be the case if the sciences we have named were preceeded by a short and practical course of logic. Before being told *what* to think the budding engineer should be shown *how* to think. This is more particularly necessary on account of the far from perfect way in which science is taught in many of our schools and colleges. Arithmetic is dealt with as if it were a set of conjuring tricks, the main object of which was to find out the price of eggs a dozen when a certain number turn out to be bad. Chemistry is the science of juvenile fireworks. Mechanics is a dodge for remembering several "systems" of pulleys, "orders" of levers, and the "five mechanical powers or simple machines," to say nothing of the first, second and third laws of Newton, the "laws" of thermodynamics, and of falling bodies. Mathematics is either overladen with formulæ, which obscure a principle instead of elucidating it, with problems which harden the mind in tricks, or with graphic methods which are remembered rather than understood. There is, in short, a general obscuration of fundamental principles under a dazzling show of phenomena or a puzzling array of problems. Pure mathematics, in its purity, is, of course, nothing less or more than formal logic; and it is for this reason alone that the study of EUCLID'S geometry exercises so healthy an effect on the youthful mind. It is greatly to be regretted that a falsely utilitarian tendency exists in some quarters to oust euclid, and replace it by more modern geometry; for this more modern thing, although more in touch with practice, is far less directly and convincingly logical.

But even were the other sciences taught in an ideal manner, there would still be a strong argument for logic as a part of an engineer's training. The fact that the sciences we have named are isolated from engineering, and taught previously to it, is, indeed, the very reason why logic, too, should be isolated and separately taught. If logic is so integral a part of every science which is the basis of engineering, it should on that account receive due consideration; which it can only receive by separate attention. If, for example, it were proposed to abolish the practice of teaching pure mathematics, leaving the student to pick up his mathematics as he went along with his physics and mechanics, the outcry would be loud and convincing. Yet logic is only an extension to concrete thought of the processes of abstract thought implied in pure mathematics. Logic does for the world of ideas about machines and energy what mathematics does for the abstract world of space and number.

Another objection which is often opposed to the teaching of logic in schools and technical colleges is that it is "dry," uninteresting and abstruse in the highest degree. In the first place, this is not a valid objection, because students do not go to class to be amused. In the second place, there is no reason why logic, any more than trigonometry, should be dry and uninteresting, and the elements of logic are not abstruse. Many of the systems of logic, especially those which follow BOOLE in his attempt to establish a system of logical calculus by means of which one might think by signs and wonderful formulæ, are certainly both uninteresting (except historically) and unnecessary. But the most important branches of logic—the logic of fallacies, of dilemmas, and of probabilities—are capable of even a fascinating treatment. The well-known "Adventures of Sherlock Holmes" is an admirable text-book on these branches of logic, and is even recognised as such in more than one medical college in this country. It is sometimes said that every really practical man, however badly educated, has an instinctive form of logic which prevents blunders or quickly remedies them,—a sort of habit, founded on experience, the reasons for which the man is generally quite ignorant of. His conduct is logical but his logic is unconscious. This is undoubtedly often, though not always the case. Where it is the case, the intuitive faculty would receive valuable assistance and development from education, as every intuitive faculty would do. Where it is not the case, education will generally train into activity a latent power, or will implant an absent one. In every case, direct education along scientific lines must enormously increase the probabilities of correct thought and sound judgment.

The difference between a logical and an illogical engineer is all the difference between the man who can forsee a breakdown or a mishap and avoids it, and the man who goes bungling headlong into it, making "confusion worse confounded" by his ridiculous attempts to clear himself. It is the difference between the man who can adapt himself readily to altered conditions, and the man who goes on in the same old-fashioned, hum-drum, rule-of-thumb manner wherever he may be. It is the difference between progress and retrogression; between a successful engineer and one who finds life a failure.

THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 368.)

It was stated in the chapter on "Mounting," that a heavy deposit is produced more quickly under a liquid than in a gas. For this reason it is best to flash in a gas, at any rate in the case of small-current filaments, as a thick deposit is not required. As a matter of fact, the deposition of carbon always takes place from the gas, even when done under the surface of a liquid. The liquid in contact with the filament is intensely heated, and by the time the filament is red hot the liquid round it is boiling so violently that the vapour alone comes into contact with it. It is this vapour which is decomposed and produces the deposit on the filament. There is produced in this way a hydrocarbon vapour of great density surrounding the filament, and hence the rapid deposition of carbon. In reducing the resistance of a filament by flashing, it is necessary that the process be not too rapid, or a slight error in stopping the current at the right moment will considerably overstep the mark. For thin and high-resistance filaments, such as for 100-volt, 16-c.p., or 8-c.p. lamps, the process must be made much slower than for filaments for lamps which will take several amperes of current. It is consequently easier to flash low-current filaments successfully in a gas than under a liquid, and the gas may further be considerably rarefied.

Ordinary illuminating gas can be used for flashing in at atmospheric pressure. In this case the apparatus required is very simple, as shown in Fig. 11. A is a glass bell jar ground flat on the top and bottom, so that with the aid of a little grease it stands gas-tight on the brass base-plate B. Through this plate pass the tubes C and D, one being the gas supply and the other the exhaust pipe. E is a plate made of hard

* Abstract from a book to be published shortly by *The Electrician* Printing and Publishing Company (Limited). All rights of re-publication reserved.

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wood, which carries two spring clips, G G, for holding the filament H. On the upper side of this plate are two metal contact plates, F F, connected with G G, the whole of this arrangement being removable. A spring contact arrangement, K, makes the electrical connection with F F, and at the same time holds the plate E firmly upon the top of the bell jar so that it is gas-tight. To work the apparatus, a filament is put into the clips which are then inserted in the jar, and the spring contacts are let down on the top. Gas is then turned on through G, and air and gas escape through D. In a short time there will be very little air left in the jar, and the current may be turned on and gradually increased by means of a regulating resistance, until the filament is brightly lighted up. The deposition of carbon now begins, and the resistance of the filament becomes lower and it gets much brighter. This, perhaps, at first sight appears curious, as it will be remembered that when depositing on a joint the joint became dull. Whether the filament or joint becomes brighter or duller as the deposition proceeds, simply depends on the amount of resistance in series with it. In starting a high-resistance filament it probably requires all or nearly all the available electrical pressure to light it up, and consequently the regulating resistance is mostly if not all cut out. As the resistance of the filament decreases the current increases, while

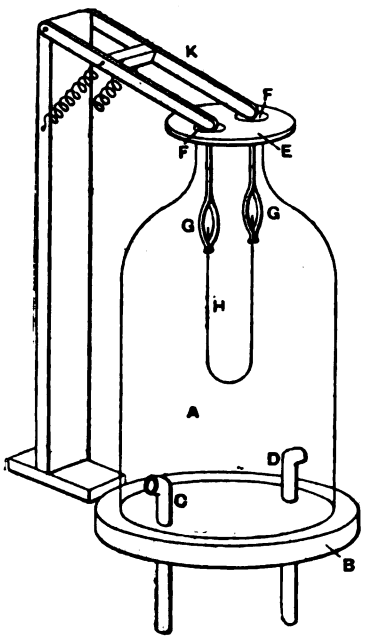
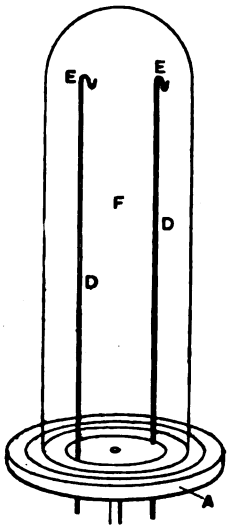


FIG. 11.

the volts remain the same, or nearly so. The filament consequently becomes brighter, and the temperature must be kept down by adding resistance. On the other hand, if, when the filament is lighted up, there is a resistance in circuit greater than the resistance of the filament, it will become duller as the deposition proceeds, for, though the current through it will be greater than at first, the difference of potential at the ends of the filament will be less in a greater ratio, and there is consequently less power being expended in it. Some of the regulating resistance must consequently be cut out to keep the filament bright. The total E.M.F. used should be just sufficient to light the filament up to the required brightness for the deposition, without any extra resistance in the circuit. As the deposition proceeds and the resistance of the filament falls, resistance must be added to the circuit in order to keep the temperature of the filament constant. More and more resistance has thus to be added until the added resistance is equal to one-fourth of the resistance of the filament when first lighted up. When this point is reached the resistance of the filament itself will also be one quarter of its original resistance. If the deposition is continued beyond this point, the added resistance is gradually cut out of the circuit again, as the filament henceforth gets duller instead of brighter as its resistance continues to fall. It is here assumed that the total E.M.F. is kept constant and that the same number of watts are expended in the filament throughout the process in order to maintain it at the constant temperature. As a matter of fact more power is required as the process proceeds, owing to the increase in thickness of the filament, so that the greatest amount of extra resistance required will not be so much as one-fourth of the original resistance of the filament. It is not often that filaments are flashed to the extent of reducing their resistance to one-fourth of the initial value.

The filament must, therefore, be kept at the required brightness by the variable regulating resistance in series with it. When the ohm-meter or galvanometer indicates that the required resistance is reached, the current is immediately turned off, and the filament is taken out and a fresh one put in.

The process about to be described, in which pentane is used, is capable of giving the filaments a very thin coating of deposited carbon. A circular brass base-plate, A (Fig. 12), turned perfectly true and free from flaws is fixed to the bench. A small hole, one-eighth inch in diameter, passes through the centre. Into this hole is screwed and soldered the end of a brass tube B, which passed through the bench or table. Upon A is a flat rubber ring, C. The glass receiver D, which may be about 11 inches high and 2½ inches in diameter, stands on the rubber ring. The whole of the clip arrangement on the top of the receiver can be lifted off. It consists of a vulcanite disc, E, underneath which is another rubber ring. Through the disc pass two brass rods, G G, ending in the spring clips



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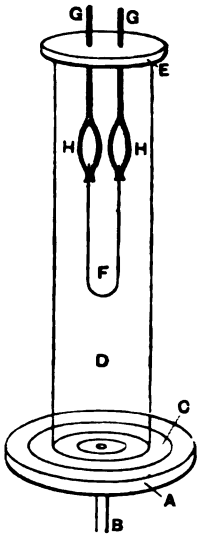

FIG. 13

H H, for holding the filament F. Four of these apparatus may be fixed close to each other on the same bench, so as to be operated by one person.

Another arrangement is that shown in Fig. 13. Two metal rods, D D, pass through the base plate A, from which they are insulated, and terminate in the hooks E E. A glass shade, F, covers the whole and stands on the rubber ring on A. The filament is held in a clip such as that showed in Fig. 14. The metal parts C C are insulated from each other by mica, A, bound round with metal B. The clip is hung by the eye-pieces D D on the hooks E E (Fig. 13). Mica should be used for the insulation, as other insulating materials may not be able to stand the heating to which they will be subjected during a prolonged flashing.

Fig 15 is a diagram of the vacuum connections. A A', B B' are the bases on which the receivers stand. The arrangement shown is such that A A' can be worked while B B' are being pumped. There is a syphon mercury vacuum gauge C C C C, about six or eight inches high, for each receiver. This kind of gauge is necessary. A barometer tube gauge is too large and clumsy, and is apt to get broken when the vacuum is destroyed, owing to the impact of the mercury with the top of the tube. Moreover, the scale must be a movable one, so that it can be raised or lowered according as the barometer

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rises or falls, or the true state of the vacuum in the receivers cannot be known. A syphon gauge always shows the actual state of the vacuum, whatever the atmospheric pressure happens to be. D D′ are two-way cocks connecting A to A′ and B to B′. E E′ are three-way cocks which will connect A A′ or B B′ either to the air by F F′, or by the three-way cock G to the pentane resevoir H, or to the vacuum pump K. The method of working is as follows :—

Filaments to be flashed having been put into the receivers on A A′, the cock D being open, the cock E, as shown in the diagram, connects A A′ to G, and through G to the vacuum

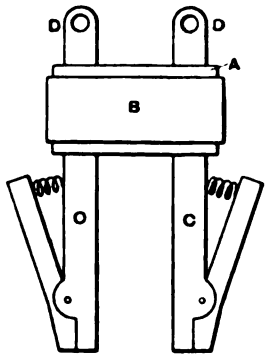

Fig. 14.

pump, which may be at a distance in the engine room of the factory, and driven by power. A vacuum is soon produced in the receivers on A A′, and when it arrives at about six inches pressure of mercury its progress can be watched on the gauge C C.

It is essential in this method of flashing that all joints, pipes, and cocks be absolutely air-tight. It might be supposed that arrangements such as shown in Figs. 12 and 18 would not be air-tight. Standing with their own weight on the base-plates the glass cylinders would not be tight, but, as soon as the vacuum is turned on, the pressure of the air forces the cylinder

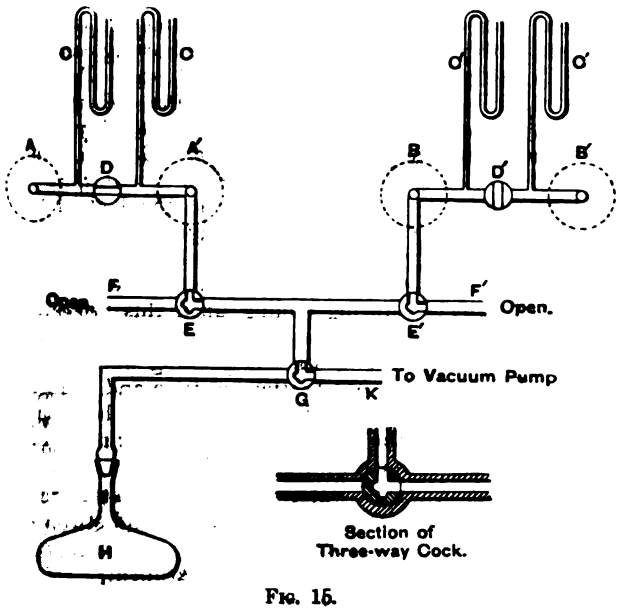

Fig. 15.

so tightly against the rubber rings that the arrangement does not leak, and, if properly made, it will hold a vacuum for hours. Of course, the arrangement shown in Fig. 18 with only one rubber joint is less likely to leak than the one (Fig. 12) where the filament is inserted through the top of the cylinder.

The vacuum is applied until the difference in level of the mercury in the gauges is about half an inch. This is as far as most mechanical air-pumps will go in practice. The cock G is then turned, disconnecting the receivers A A′ from the vacuum pump, and connecting them with the reservoir H, which has previously been partly filled with pentane. Pentane vapour now passes from H along the tubes into the receivers A A′. This is apparent by the increased pressure indicated by the gauges C C. The vapour should be allowed to enter until the gauges show five inches difference in level. The cock G is then turned back again, connecting A A′ with the vacuum pump, and the vacuum is again reduced to about 1½in. by the gauges. The cock E is then turned so that A A′ are disconnected entirely. The cock E′ is now turned so that B B′ are connected through G to the vacuum pump. The condition of A and A′ is now the same, and the cock D is turned, so that A is shut off from A′. Current is now applied to the filament in A. The increase in temperature of the gas in the receiver, produced by the heating of the filament, causes increased pressure, and the gauge shows a decreasing vacuum. The filament is brought to a bright white heat, at which it is maintained by means of the regulating resistance, until the indicator which is used shows that it has received a sufficient coating of carbon. The filament in A′ is then treated in the same way. The cock D may then be opened, and E turned so as to admit air through F into A and A′. The filaments are then taken out and fresh ones put in. The same process is then repeated with the filaments in B and B′. While the flashing is going on in one side of the apparatus the other side is being pumped.

This may appear a complicated arrangement of pipes and stopcocks, but with a little practice it can be worked very quickly. With the apparatus shown in Fig. 18, the electrical connections with the different filaments is made by means of a switch, while with the other form (Fig. 12) one clip on the end of a flexible wire makes connection to the wires G G. By this latter method the chances of turning the current on to the wrong filament are less than with the switch arrangement, as the operator is apt to forget to put the switch over, whereas in the other arrangement the clip must be removed from the top of the apparatus before the filament can be taken out.

Hard, white, deposited carbon has only about one-tenth of the specific resistance of carbon made from amyloid, the resistance of the deposited carbon of that kind being about 350 microhms per cubic centimetre, and that of amyloid carbon 3,500 microhms at a temperature of from 6 to 2 watts per candle power.

At the ordinary temperature of the air the deposited carbon is about two and a-half times greater, and the amyloid variety one and a-half times only.

(To be continued.)

BOILER TESTING.*

It is most desirable that all trials should be so conducted and recorded that comparison with other similar trials may readily be made. All instruments employed—such as pressure gauges, thermometers, &c.—should be compared with standards before and after the trials; a careful analysis of two or three representative samples of the fuel used should be made, or, in default of this, a well-known coal of good quality, such as Nixon's Steam Navigation, of which the constitution has been tolerably well ascertained, should be used.

In complete evaporative trials it is usual to form a heat balance-sheet as below:—

Heat received.	B.T.U.	Per cent.	Heat expended.	B.T.U.	Per cent.
To calorific value of coal.....	Q	100	By dry steam	Q_s	
			„ priming water ...	Q_p	
			„ exhaust	Q_e	
			„ incomplete combustion	$Q_{i.c.}$	
			„ radiation, &c.....	Q_r	
			„ losses unaccounted for	Q_u	
	Q	100		Q	100

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It is often considered sufficient to ascertain the weight of feed water evaporated per pound of coal, neglecting errors due to possible priming; but in careful evaporative trials observations are made of the durations of the experiments, the quantities and analyses of the coal used, the quantities of ash remaining, the quantities and temperatures of the feed water, the steam pressures, the amounts of priming water in the steam, the temperatures and analyses of the flue gases, and of the losses of heat by radiation, &c., from the boilers.

Coal.—At each trial two or three small quantities (a few pounds each) of the coal should be weighed; then dried and weighed again to determine the average amount of moisture present per pound of undried coal (*i.e.*, coal as used in the trial). Prior to analysis the samples of coal should be thoroughly dried as the working out of results of trials with coal of the same kind, but containing different amounts of moisture, is thereby facilitated.

The principal active constituents of coal are carbon, hydrogen, and oxygen; and denoting the weights of these in pounds per pound of *dry* coal by C, H, and O respectively, we have:

$$Q_1 = 14545\,C + 62032\,(H - O/8),$$

where Q_1 is the *total heat of combustion* in British thermal units per pound of *dry* coal. A part of this total heat of combustion is used up in vaporising the water formed by combustion of the hydrogen, and must be subtracted from Q_1 in order to give Q_2, the *calorific value* of one pound of *dry* coal in B.T.U.; if the temperature of the coal is t'°F, and if—for definiteness—the water formed is taken to be vaporised at this temperature, we have

$$Q_2 = 14545\,C + (52007 + 6{\cdot}255\,t')\,H - 7754\,O.$$

If at any trial each pound of undried coal is found to contain on an average q lb. of water (and, consequently, $1 - q$ lb. of dry coal), the *calorific value* of the *undried* coal (Q) is obtained by subtracting from $Q_2\,(1 - q)$ the heat required to evaporate q lb. of water from and at t'°F: hence

$$Q = (1 - q)\{14545\,C + (52007 + 6{\cdot}255t')\,H - 7754\,O\} - (1113{\cdot}9 - 0{\cdot}695t')\,q;$$

and since t' will generally be from 60°F to 70°F, Q may be found with sufficient accuracy from the formula

$$Q = (1 - q)\,(14500\,C + 52400\,H - 7750\,O) - 1070q.$$

It is convenient to weigh out the coal to be used into sacks containing 100lb. or 112lb. each, and these sacks may with advantage be numbered and ticketed to avoid risk of error; the time at which each sack is used during a trial should be noted, as this enables a graphic representation of results to be made. If the duration of a trial exceeds eight to ten hours, either of the two following methods of ascertaining the quantity of coal properly debited to the test may be employed:—

(*a*) The boiler is thoroughly heated up* and steam raised to the normal pressure with unweighed coal; then the fire is drawn and the trial commenced with weighed coal and a small weighed quantity of dry wood. At the conclusion of the trial the fire is again drawn, and this when cool is divided into incombustibles (clinkers picked out by hand and small ashes passing through, say, a half-inch sieve), and combustibles (the remainder). The latter may be taken as good fuel and deducted from the total quantity thrown on the grate. An allowance must be made for the wood used in re-lighting, and 2¼lb. to 2½lb. of dry wood may be taken as equivalent to 1lb. of average coal.

(*b*) The boiler is thoroughly heated up, steam raised to the normal pressure, and the condition of the fire carefully noted; the trial is then commenced with weighed coal; at the conclusion of the test care must be exercised to leave the fire in the same state as at the beginning of the test. This latter method is not so accurate as the former, especially in trials of short duration, on account of the difficulty of judging whether the fire is in the same condition at the end as at the beginning.

* Sufficiently to get the boiler and brickwork to its ordinary working temperature; this may take two or three days if the boiler has not been recently used.

In all cases ashes which fall through the grate during the trial should be thrown on again to ensure complete combustion, and the clinker and ash should be weighed.

Steam Pressure.—This should be noted at definite short intervals throughout the trial, unless a recording pressure gauge is used. The temperature of the steam, corresponding to the observed pressure, may be obtained from tables, or by the formulæ.

Feed Water.—This should invariably be measured directly in tanks, and not estimated from the speed and capacity of a pump. The tanks employed, from which the boiler should be fed alternately, may be calibrated in the first instance by filling from cans of known capacity; and it is desirable to note the quantity of feed water supplied to the boiler at definite intervals (say every half-hour) during the trial, and not merely the total feed. Care should be taken that the height of the water in the boiler gauge-glass is the same at the end as at the beginning of this trial.

If W_f = weight in lbs. of feed water supplied to boiler per hour,
t = mean temperature in °F. of feed water,
T = mean temperature in °F. of steam and priming water,
W_c = weight in lbs. of coal burnt per hour,
w = weight in lbs. of priming water per lb. of wet steam or per lb. of feed water (*see* Priming Water in Steam),
U′ = evaporation in lbs. of wet steam (or feed water) per lb. of coal,
U = evaporation in lbs. of dry steam per lb. of coal,
Q_s = heat in B.T.U. given to U lbs. of dry steam,
Q_p = heat in B.T.U. given to U′w lbs. of priming water.
E = efficiency of boiler;

then $U' = W_f/W_c$,
$U = W_f(1 - w)/W_c$,
$Q_s = U\,(1113{\cdot}9 + 0{\cdot}305\,T - t)$,
$Q_p = U'w\,(T - t)$,
$E = Q_s/Q$;

where Q is, as previously, the calorific value in B.T.U. of 1lb. of undried coal.

Priming Water in Steam.—To determine the weight of priming water per lb. of wet steam is rather a delicate operation, and demands a considerable amount of care to obtain reasonably accurate results. The following calorimetric method is fairly good if carefully carried out. Take a can capable of containing, say, 250lb. to 300lb. of water, and suspend it by cords inside a larger vessel (preferably metal) so that it hangs clear and is completely protected from draughts. Weigh into the smaller vessel, say, 200lb. of water, and note the temperature; then inject steam from the boiler into this water, and note the temperature every quarter-minute or so, stirring thoroughly the while. When the temperature has risen 40° F. to 60° F. cut off the steam, and note the temperature at short intervals during cooling until this becomes very slow. Then weigh the water and condensed steam carefully to ascertain the quantity of steam and priming water which has been injected. From the observations of time and temperature during heating, and also during cooling, the heat lost by radiation, &c., during the first part of the experiment may be approximately determined, as described later.

If W_1 = weight in lbs. of water in the calorimeter including water equivalents* of the inner vessel and stirrer at the beginning of the experiment,
W_2 = Ditto ditto at the end of the experiment,
t_1 = temp. in °F. of water in calorimeter at the beginning of the experiment,
t_2 = Ditto ditto when steam is cut off; this will be the highest observed temperature if the stirring is thoroughly done,
P = absolute (gauge + 14·7) pressure in pounds per sq. in. of the steam,
T = temperature in °F. of steam at absolute pressure P,
L = latent heat in B.T.U. of water at T °F.,
h = heat lost by radiation &c., from calorimeter, during heating by injection of steam, in B.T.U. (*see* later for means of approximately determining h),

* The water equivalent of the inner vessel is the product of its mass into the specific heat of its material, and similarly for the stirrer.

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w' = equals total weight in lb. of priming water carried by steam into the calorimeter,

w = weight in lbs. of priming water per lb. of wet steam or per lb. of feed water;

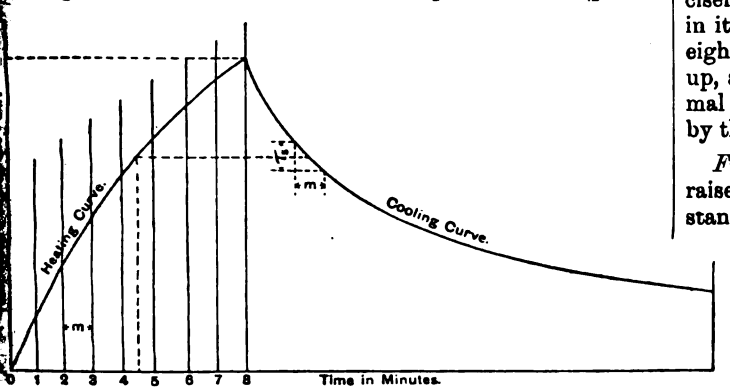
n $w' = (W_2 - W_1) - \{W_1(t_2 - t_1) - (W_2 - W_1)(T - t_2) - h\}/L$;

l $w = w'/(W_2 - W_1)$.

To appoximately determine h construct curves of time and nperature for both the heating and cooling experiments (*see* ure), and divide the duration of the heating experiment o eight to twelve equal periods of, say, m minutes each; the t lost in any given one of these heating periods may be en as proportional to the fall of temperature in that cooling iod of m minutes which has the same mean temperature as the ting period considered—thus in the figure the loss of heat the fifth heating period is proportional to τ_5 °F., which is the l of temperature in the cooling period of m minutes, having e same mean temperature as the fifth heating period. The al heat lost in the heating experiment (h) will be propornal to the sum of the τ s, obtained as described, for all the ting periods, and will be given approximately by the formula

$$h = \tfrac{1}{2}\{W_1 + W_2)\,\Sigma(\tau)\}.$$

Flue Gases.—At intervals during the trial the temperature of flue gases should be taken*, and samples collected (perfer-



ly over brine to diminish the absorption of CO_2 as much as ssible), and analysed. The exhaust gases analysed are dry, e., without the steam previously present with them in the ues and chimney, and consist practically entirely of carbon ioxide, carbon monoxide, oxygen, and nitrogen. If C, H, and represent (as previously) the weights in lbs. of the carbon, ydrogen, and oxygen respectively present in 1lb. of *dry* coal, the weight in lbs. of water in 1lb. of undried coal, and if

a = Weight in lbs. of CO_2 per lb. of dry exhaust gases,
b = weight in lbs. of CO per lb. of dry exhaust gases,
c = weight in lbs. of O per lb. of dry exhaust gases,
d = weight in lbs. of N per lb. of dry exhaust gases,
t' = mean initial temp. in °F of coal (*see* earlier),
t'' = mean temp. in °F of exhaust gases on leaving boiler flues.
Q_e = heat in B.T.U. carried up chimney and lost by exhaust gases per lb. of coal,
Q_{ic} = heat in B.T.U. lost by incomplete combustion, as manifested by presence of CO, per lb. of coal,

hen the weights in lbs. of the dry exhaust gases and of the team accompanying them are $\{77C(1-q)\}/\{3(7a+11b)\}$ and $q+9H(1-q)\}$ respectively per lb. of undried coal burnt; ence, taking the mean specific heat of these gaseous products rom the coal at 0·238 and the heat of combustion of carbon urnt to CO as 4452,

$$Q_e = 0{\cdot}238\,(t'' - t')\left[(1-q)\left\{9H + \frac{77C}{3(7a+11b)}\right\} + q\right] \text{B.T.U.}$$

$$Q_{ic} = 111{,}000\,C\,b\,(1-q)/(7a+11b).$$

Further, the weight of air actually used per lb. of undried coal is $\{100\,C\,d\,(1-q)\}/\{3(7a+11b)\}$ lbs.†

* When the temperature does not exceed 650° F. a mercurial thermometer may be used; for temperatures above 650° F. some form of pyrometer must be employed.

† This is also represented by the expression—

$$\frac{100(1-q)}{23}\left\{\frac{C(56a+44b+77c)}{3(7a+11b)} + 8H - O + \frac{8q}{9(1-q)}\right\},$$

which affords a check on the analysis.

Radiation Experiment.—This consists in observing the quantity of coal required to maintain the normal steam pressure when the boiler stop-valve and feed-valve are closed, the coal used per hour being measured precisely as in the evaporative trial already described. The firegrate area is sometimes reduced by bricks, as in the boiler trials of Messrs. Bryan Donkin and Kennedy*, so that the conditions of firing may be equally favourable with those in the evaporative test. Care should be exercised during this trial that the safety valve does not lift.

If w_1 = weight in lbs. of coal used per hour in the evaporative test,
w_2 = weight in lbs. of coal used per hour in the radiation test,
Q_r = heat in B.T.U. lost by radiation, &c., per lb. of coal used in the evaporative test;
then $Q_r = w_2\,Q/w_1$ very approximately.†

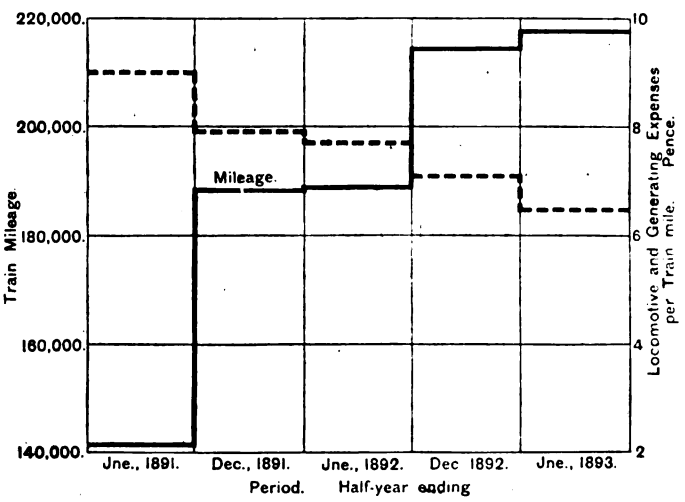
Heat Losses Unaccounted for.—These are obtained by difference,
and if Q_u = heat in B.T.U. lost, and unaccounted for explicitly, per lb. of coal used in the evaporative test;
then $Q_u = Q - (Q_e + Q_p + Q_t + Q_{ic} + Q_r)$.

Fuel for Keeping Steam on Light Load.—This trial is precisely similar to the radiation test, except that the fire-grate is in its normal condition as regards area. The trial should last eight to ten hours, the boiler having been previously heated up, and the coal in lbs. per hour required to maintain the normal steam pressure is simply the total quantity used divided by the duration of the test in hours.

Fuel for Raising Steam.—The quantity of fuel required to raise steam depends on the length of time the boiler has been standing unused; hence this time should be definitely stated in every record of such a test. The wood used for lighting up should be allowed for, and—on the boiler having been heated up and steam raised to the normal pressure—the fire should be drawn, and the *combustibles* then on the grate deducted from the total fuel used.

THE CITY AND SOUTH LONDON RAILWAY.

The steady increase in the train mileage of the City and South London Railway and the equally steady decrease in the locomotive and generating expenses per train mile run are shown in a striking manner on the accompanying diagram. The



reduction of the locomotive and generating expenses from 9d. to 6·48d. in less than three years is a remarkable instance of the saving virtues of actual experience, and it should embolden capitalists who are hesitating about sinking their money in electric railway tubes.

* See *Engineering*, Vol. 50 *et seq.*, for accounts of these trials, the mode of presenting the results of which forms an admirable model for similar trials.

† Probably Q_r is actually rather greater than this.

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TRANSMISSION OF POWER AT BIBERIST.

The following particulars of an application of water-power for the purpose of driving a paper mill at a distance of 20 miles from the fall, may be of interest. The owners of the Biberist Paper Mills finding that, on account of the need for increased power at the mills, the neighbouring water supply was inadequate, determined upon utilising the surplus of the water power which was employed in driving two other of their paper mills on the banks of the Suze. One of these mills is situated at Frinvilliers, in the Bernese Jura, and the other at Ronchatel, about ½ mile further up the stream. The fall between the two is about 45ft.; and, by conveying the tail water of the upper mill through a canal, cut partly in the solid rock and partly sustained by masonry, this fall is utilised without injuring the supply of power to the lower mill. The flow of water varies considerably according to the season; but, throughout the greater part of the year, there is a surplus of not less than 400 H.P. Acting upon the advice of Prof. Denzler, of Zurich, the managers of the mills decided to electrically transmit this power to the Biberist mills by means of a high-pressure current carried through an aerial line over the mountains.

The work was placed in the hands of the Compagnie de l'Industrie Électrique, of Geneva, and was carried out in the following manner, under the direction of M. Goichot, their engineer.

At the generating station at Frinvilliers a 400 H.P. turbine, constructed by MM. Escher, Wyss, and Co., of Zurich, has been placed, the turbine working on a vertical axis at a normal speed of 120 revolutions per minute. This turbine is geared, by means of a bevel wheel and two pinions, to two continuous current dynamos of the Thury pattern, which are arranged respectively on the left and right of the turbine. The dynamos run at a normal speed of 275 revolutions per minute, and their output is 40 amperes at 3,300 volts each. They are connected in series, giving the extraordinarily high pressure (for continuous-current closed-coil machines) of 6,600 volts. The armature winding is of the Gramme ring type, and the magnets, which are entirely of wrought iron, have six poles. The commutators are 3ft. in diameter, and consist each of 442 sections of hard-drawn copper insulated with mica. There are 18 carbon brushes on each machine, arranged in six sets of three abreast. The dynamos are supported on adjustable bolts placed on porcelain insulators, and an insulating floor is provided all round the machines. The weight of each machine is about 31·5cwt., and, under test, a commercial efficiency of nearly 93 per cent. has been obtained.

The two motors at the Biberist mills are also connected in series. They are identical with the generators, and each delivers 155 H.P. at 200 revolutions per minute, giving a total efficiency of the entire plant of about 78 per cent. The two lines joining the generators with the motors are constructed of bare stranded copper, 7mm. in diameter, equivalent to No. 2 S.W.G., their total resistance causing a drop of 600 volts, or 9 per cent. The lines are carried on wooden poles and, their exposed position rendering them very liable to be struck by lightning, they are protected by simple lightning arresters placed on many of the poles, and by condensers and impedance coils placed at the two stations at the ends of the line.

THE PROPOSED MUNICIPALISATION OF THE TELEPHONES AT GLASGOW.

At the meeting of the Glasgow Town Council, on Thursday of last week, Mr. STARKE, in moving the approval of the minutes of the Telephone Committee, and of the relative minute of the Finance Committee, said that the Telephone Committee was appointed a few months ago to consider the municipalisation of the telephones. The Committee had given the subject the fullest consideration, and they had resolved to recommend that an application be made to the Postmaster-General for a license to supply the community with an efficient telephone service. A deputation of the Telephone Committee afterwards met with the Finance Committee, for the purpose of seeing as to ways and means. The Finance Committee heard their statement, and gave it a hearty and generous response, and "resolved to concur in the recommendation of the Special Committee that an application should be made for a licence. They further agreed to recommend that the Corporation should advance the sum necessary to start the system." If one might judge from what had appeared in the public prints, among the citizens and the outside public generally, there was nothing but the heartiest good wishes towards this proposal. All authorities on the subject were at one in this, that the system they were using in Glasgow and throughout Great Britain was most unsatisfactory—in fact, it was the worst in Europe. It was expensive, and, from the special circumstances in which the Company was placed, it could never be otherwise except on conditions to which the Council would never agree. There was a general feeling that the matter must be taken up by the State or by the municipal authorities in connection with the State. It was becoming that Glasgow, with the *prestige* she held as a bold and successful exponent of municipal enterprise, should step out and be the first in the direction of dealing with the telephone service. The Committee were following the principle of doing for the citizen in his corporate capacity what he could not do so well in his individual capacity. If the telephone system were developed, as it was likely to be if the recommendation were adopted, it would be brought within the reach of the humblest citizen. The present system in Glasgow, which was a single-wire system, was totally unfitted for such a great city. The Company could not improve the present system unless they erected twin wires overhead or got possession of the streets. Suppose they adopted the twin-wire system, they would have the immense crowd of overhead wires duplicated. The only alternative was for the Company to get possession of the streets and lay the wires underground; and this the Corporation would not agree to. As to the financial arrangements 3,500 subscribers at £5 per head would amount to £17,500, and there would be at least 2,000 private instruments, which would make the income £19,500. The working expenses might be reasonably taken to mean 50 per cent. of the revenue, while the Government licence would be 10 per cent. on the net income. Then it was proposed that 5 per cent. should be set aside every year as a sinking fund, so that the whole should be wiped out in 20 years. Allowing £2,000 for sundries, he estimated they would have a clear revenue of between £5,000 and £6,000 per annum.

Bailie ALEXANDER seconded the motion. He had been terribly annoyed lately with the present telephone system. He had been trying since July 21st to communicate by telephone with a firm, and had not yet succeeded.

Bailie PRIMROSE said he entered the room with an open mind, but after listening to Mr. Starke he had come to the conclusion that he asked them to embark on a rash and Quixotic scheme. His intention was to move that the whole subject be remitted to a committee for further consideration, with instructions to report fully and in detail. They had lately municipalised the tramway system, but he denied that this was a parallel case, for the tramways were a monopoly, and they touched civic life at every point. The acquisition of the telephone system was not a municipal but an imperial question. The Government had assumed control of the telegraph system with advantage to the country, and was it not probable that the Government, in acquiring the trunk telephone system, recognised that at no distant date Governmental supervision must be extended? for in the limitations they were imposing they kept the question as simple and easy a one as possible. Mr. Starke said that they were only making an application for a licence to the Postmaster at present, but was it desirable to apply for a licence with their minds half made up, without being fully convinced as to the rudimentary principles involved? Supposing the municipality agreed to establish a telephone system, it would simply involve the community, as it did in Manchester when the Mutual Company existed, in being subscribers to both. That was one great difficulty he saw in municipalising the telephones. If an Act were passed empowering all communities to adopt the telephone system as part of municipal work the difficulty would not end there, because many of the municipalities, probably for reasons of prudence or lack of enterprise, would not avail themselves of it, and what intermediate link were they to have except a national company like the present? He was not arguing for limitation of municipal enterprise; but he was endeavouring to point out that there were hard initial difficulties which Mr. Starke had touched and lightly passed over. In municipalising the telephones they would be at once confronted with the wealthy and powerful opposition of the present company. With regard to the financial proposals, he thought they could, without any breach of courtesy, be described as crude and problematical. What data had Mr. Starke given them that had been endorsed by any specialist? What were they to make of the statement that for a capital expenditure of £15 for each user this service could be provided. He would like to see that statement very authoritatively put down in black and white and the details wrought out. On the bald and unsatisfactory information placed

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before the Council that day, he felt justified in proposing the amendment he had submitted.

Mr. D. M. STEVENSON supported the motion. He pointed out the powers of telephone companies with regard to carrying wires under streets, and remarked that Bailie Primrose asked for more data, and yet Mr. Starke was stopped because he was giving them too much information. The Corporation must have the monopoly of their streets. He did not suppose that they would give it away to any rival company. Again, there was no likelihood of the State taking possession of the local wires.

Mr. COLQUHOUN said he very seldom differed from Bailie Primrose, but he did so on this occasion. The position Mr. Starke asked the Council to take up was that merely in the meantime of applying to the Post Office authorities for a licence to establish a telephone system. Beyond that there was nothing in the proposal of Councillor Starke that committed the Council to the expenditure of money without having the fullest details before it, and without having the most perfect assurance that money so expended would be profitably expended. What was the Municipality to do when they were being victimised—he could not use a less strong word—by the National Telephone Company? It might be asked, how were they being victimised? In reply, he said that before they could establish an overhead system of electrical tramways they must provide a system of insulation. That position, to put it plainly, was one of the most impudent ever taken by a private company. He did not know what Bailie Paton, the convener of the Tramway Committee, would have to say for allowing the National Telephone Company to get a clause in the Tramway Act making such a thing possible, but the only way in which they could meet the Telephone Company was by taking the step Mr. Starke recommended. He therefore besought the Council to adopt the motion.

Bailie GRAHAM supported Bailie Primrose's amendment. He did not defend the present telephonic service. During the past three weeks his experience had been of the most terrible character, and he had latterly given up using the telephone, as it led to more bad language than he cared to employ. But the proper solution of the question was to press upon the Government the propriety of acquiring the telephone service of the country.

After some discussion, Mr. STARKE agreed to omit the last clause of the motion recommending the Corporation to advance the amount necessary to start the system.

The Council divided, when the motion as amended was adopted by 27 votes, against 21 for the amendment of Bailie Primrose.

ELECTRIC ROCK-DRILLING MACHINERY.*

BY A. L. STEAVENSON.

Ironstone mining in Cleveland has now extended over a period of forty years, during the whole of which the writer has been connected and conversant with its progress.

Electric Drill.—When electricity became applicable, its simplicity and regularity in working seemed to offer an inducement for a trial. With the assistance of Mr. Robert Clough, engineer to the mines and collieries of Messrs. Bell Brothers, the writer designed a drill to be worked by this power.

Dynamo.—The current for working the drills is generated at bank by a compound-wound dynamo, having an output of 20,000 watts, and capable of furnishing a current of 50 amperes at a pressure of 400 volts, when running at 900 revolutions per minute. This dynamo is intended to supply current for working the first section of the plant, namely, three drilling machines. The current required to drive each drill varies, of course, with the hardness of the stone the drill is working in; but it may be taken that under ordinary conditions, and when the voltage at the drills is 300, the current absorbed per drill-motor is about 15 amperes, which is about 6 E.H.P.; and when a dynamometer was applied to the drill bar, 6 H.P. was obtained. The current from the dynamo is taken to a high-tension double-pole switch on the main switchboard, which is of enamelled slate, and has mounted upon it the necessary fuses, measuring instruments, &c.

Cables and Junction-Boxes.—From the switch the current is conveyed down the pit through cables covered with highly-vulcanised india-rubber. The cables are run all the way in-bye on insulators, and are kept well in sight, so that, should a fall of stone occur, the damage can be quickly discovered and set right. The main cables are run to a point at a distance of 1,000 yards from the generator; and then from this point branch cables are run to the different junction-boxes, of which there are six to each drill, commanding twelve working places. The juction-boxes were specially designed to meet the exigencies of the case, and are really a combination of a junction-box, switch, and connecting-plug. The plug is locked in position by a pin, and cannot be withdrawn without first of all lifting the switch, thus preventing sparking and wear on the contacts. Each district to be worked by the several drills is completely wired out and fitted up with these junction-boxes, so that when the drill is moved from one working place to another a box is always to be found within 50 yards distance. The plug at the end of the drill cable is then inserted, the switch on the drill turned on, and within a few seconds the drill is again at work. Much time is saved by this method.

Drilling Machine.—The motor is used not only to drive the drill gear, but also to act as a counter-balance to the weight of the drill itself and its gearing. The motor rotates a shaft, which passes through a long hollow carrying bar, and by a pair of bevel wheels causes a vertical spindle to revolve; and a bevel pinion on the top of the spindle, gearing into a bevel spur-wheel on the boring-bar, rotates the drill. The forward feed of the boring-bar is governed by two pairs of retarding wheels, which are geared in such a proportion as suits the nature of the stone. The drill is carried on a circular bed-plate, which is mounted on the end of the carrying bar, and can be turned round by hand when the binding screw is released. As soon as a hole has been drilled the full length of the screw on the boring bar a split nut is opened, and the boring bar drawn back for inserting a longer drill. In order to reach different heights, the drill can be tilted upwards or downwards by means of a semi-circular arc, which is moved by a worm, By another worm-wheel the upright pedestal can be turned horizontally round its centre. A third worm-wheel turns the long hollow bar which carries the drill.

Motor.—The motors on the drills are shunt-wound, and can easily utilise a current of 20 amperes at 300 volts pressure, giving off about 95 per cent. of what they receive. They are of the Goolden enclosed kind for mining purposes, both the armature and the commutator being completely enveloped in gun-metal cases, which are both gas and dust tight. Even should water pour over them, or a fall of stone occur, they are perfectly protected, and no appreciable damage would be done to them. The brushes used are of special carbon coated with copper. The feed for the brushes as they wear themselves away is automatic, so that they can be run for weeks together without requiring any adjustment or attention. Each drill is provided with a starting switch, placed in the most convenient position on the drill carriage itself, and arranged with resistance coils in such a manner that the drill can be started gradually, and stopped either gradually or instantaneously. Each drill is also provided with a reel of 50 yards of twin flexible cable for the supply and return of the electricity; at the end of the cable is a connecting plug for inserting into the nearest junction-box.

Working.—These electric drills were put into the hands of men who had no previous knowledge whatsoever of electricity; and the day the first drill was put into the mine it was at once set to work at the face, and has been at work ever since. The men are now thoroughly accustomed to the drills, and handle them with the greatest ease. The writer has thus tried almost every method for working drilling machines in ironstone mines, including compressed air, hydraulic power, and petroleum engines; and it is his decided opinion, as the result of this practical experience, that for simplicity in working, ease of transport, speed, facility for extension, and economy in working, the electric drill has proved itself to be in advance of any other mechanical contrivance yet introduced; and that in the future, where power has to be conveyed to any considerable distance for mechanical drilling, electricity will undoubtedly play the predominant part. The entire work was placed in the hands of Messrs. D. Selby Bigge and Co., electrical engineers, of Newcastle-on-Tyne; and Mr. Bigge devoted considerable time with the writer and Mr. Clough to working out and improving the various details of this first attempt at electric drilling in the Cleveland ironstone mines.

Output.—The joint output for one week for two of the three machines has already reached 1,577 tons with 790 holes. From 80 to 100 holes have frequently been bored by one machine in a shift, each hole averaging about 4½ft. deep. The miners are enabled to earn 7s. 7d. each shift, while the stone is got at a cost of 7½d. per ton. Powder is always from one-third to one-half more costly when drilling machines are used than is the case with hand-labour, since it suits better to blow the stone out with a larger number of holes which are quickly and cheaply drilled; this plan also makes the stone fall in smaller blocks, and so saves labour in breaking them up previous to filling.

General results.—In attempting to compare the results obtained with the several drills, the following considerations have to be borne in mind. The conditions of the seam of ironstone affect the output and cost. An open stone admits of fewer holes in one place. Then time is lost in more frequent removals of the drill, and the number of holes drilled per hour is diminished. The cost of the machine itself sometimes represents the whole and sometimes only a fraction of the total cost. Thus a petroleum drill covers the

* Abstract of a Paper read before the Institution of Mechanical Engineers.

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entire cost of its adoption. But the compressed-air drill in some cases has attached to it an average of more than a mile of pipes, and also requires its engine and compressors, as well as its share of boiler. The electric drill also requires engine and dynamo, with a length of cable depending upon the distance from the shaft; it is still so new that alterations and improvements are being made as experience is gained. The hydraulic drill, although getting its power from natural sources, needs pipes; and the exhaust water has afterwards to be pumped up to the surface. The hand ratchet-drill has been applied as yet in only one or two mines, and the tonnage rates and system of working are not yet finally settled with the workmen.

Subject to these considerations the following comparative statement may be taken to represent generally the results thus far obtained with the several drills:—

Description of drill.	First cost of machine only.	Holes drilled per hour.*	Ironstone got per shift. Tons.
Hand jumper	—	4½ft. in 45 mins.	5 to 8
Hand ratchet-drill ...	£3	not yet known	about 18
Compressed-air drill ...	250	about 8 holes	100 to 130
Hydraulic turbine.....	220	„ 8 „	100 to 130
Petroleum engine	375	„ 8 „	100 to 130
Electric drill	350	„ 10 „	140

* This includes the time lost in moving the machine to different working places.

The length of shift is eight hours from bank to bank, or, say, seven hours at the face. At the Park Mines the drills work two shifts in 24 hours, and at the other mines one shift; and six shifts per week when trade permits.

THE ART OF COMPOSING ENGINEERING SPECIFICATIONS.*

Not long ago, Mr. Theodore Cooper, a member of the American Society of Civil Engineers, and an eminent constructor of bridges, &c., addressed the students of the Rensselaer Polytechnic Institute on the important subject of engineering specifications. Mr. Cooper has had great experience, and in his address the result of practice reacting upon conspicuous common sense and trained ability in engineering business is set forth in the happiest and clearest language. He passes in review all kinds of engineering work, and every method of executing it; and he concludes in favour of the contract system. The importance of the study of specification-writing, however, does not depend wholly upon the continuance of the contract system, for when work is done at first-hand there is just as great necessity for explaining the manner of carrying out plans, and stating the nature and quality of the materials to be used, as when these instructions are to be carried out by a middleman.

Upon the supposition that a contract for any particular piece of engineering work is to be let, in the usual way, the first consideration insisted upon by Mr. Cooper is that the price should be such as will give "the expectation of a reasonable profit to the contractor." This is not to be understood as meaning that the contractor ought to have a profit in any or all circumstances, but only when the condition is observed of a proper and economical execution of the work. "I think you will find it the universal testimony of experienced engineers," says Mr. Cooper, "that, were it within their power, they would never allow a contract to be made which did not contain the expectation" already stated. The speaker was at particular pains to lay stress upon this expression of the business principle in contracting, because, as he says, it is not always kept in mind by professional men, some of whom regard the contractor as the natural enemy of the engineer. In preparing the estimate of any particular piece of work, it is the duty of the engineer, as well as of the contractor, to add to the approximately known elements of cost the reasonable contractor's profit, and also a contingency allowance "proportional to the risks involved and to the unknown elements entering into the execution." Failure to recognise this principle is a source of great injustice as between the parties to a contract. Engineering specifications are defined by Mr. Cooper as consisting of the "detailed particulars supplementing and explaining the plans of any piece of work, and governing the character of the materials and the methods of construction to be used for the same." The object of a specification is further defined as being twofold. In the first place, it is intended to enable tenderers to understand fully the character and extent of the work and what they are expected to supply and to do, in order that they may be able to make suitable estimates upon which to formulate an intelligent and proper tender. Secondly, it is intended to serve as a reference to the plans, in regard to all questions of quality of material and workmanship during execution, in order to prevent misunderstandings between the engineer and the contractor. Nothing serves better, says Mr. Cooper, in obtaining the best class of contractors and obviating friction between engineer and contractor, than a good specification, carefully and clearly expressed. On the other hand, a loosely-drawn and incomplete specification is always an attraction to the worst class of contractors, or those who have no intention of doing an honest job, but will take advantage of every weak point to get all they can out of the contract. Such men frequently tender low for jobs when they see a weak specification, trusting to make "extras" later on, or to be able to skimp in cheap material or work. Mr. Cooper lays great stress upon a matter that is to the full as important in England, with our many local customs, as it can be in America. This is the classification and nomenclature of materials used in engineering and building construction. Where there are several classes of materials and workmanship which are to be paid for at different rates, it is very essential for every class to be properly and clearly defined in language intelligible to a master workman. The use of such general terms as "first-class material," and "best workmanship," &c., as Mr. Cooper says, carry no weight except where they are expressly defined, or are taken in connection with other definite clauses. The average contractor is quick to discover the engineer's want of knowledge of the terms employed in his own specification; and is not unlikely to take advantage of such weakness, if he is an unscrupulous man. All this trouble is avoided when specifications contain plain directions, and the engineer is competent to tell whenever these are being infringed. Mr. Cooper passes on to the consideration of the vexed question of the reserve of disputes respecting the interpretation of a specification or the execution of work to the arbitrament of the engineer. He strikes the true note in giving as his opinion that no engineer has a right to insert in specifications such phrases as "to the satisfaction of the engineer," or "as may be directed," to be afterwards used for obtaining more or better material and workmanship than would be expected from the context of the specifications. They can, however, be fitly used to cover work or material which could not in the circumstances be otherwise defined; or they can be used to relieve the contractor under special conditions, by accepting some other material or work than is specified, if good reasons can be adduced for the change. Contingencies of this kind will often arise; and the great point to be borne in mind is that the reserve of reasonable discretion to the engineer is as much to the interest of the contractor as against him.

With regard to the general framing of specifications, Mr. Cooper counsels adherence to well-proved models, modified, if necessary, for the special purpose. The model must first be carefully studied, in order that its theory and general purport, as well as the meaning of the various clauses, may be understood. The wording of old and clearly-defined clauses is in no case to be tampered with. "A specification is not intended to be a treatise on the refinements of engineering theory, but a practical set of rules and conditions upon which work is to be let and constructed. A specification should therefore be reasonably brief and positive." A general specification need not provide for all the special minor conditions and exceptional cases may possibly occur in practice; but, on the other hand, an accepted model specification is to be regarded as an "accumulative growth," and will contain many requirements that cannot be safely set aside, though they may never come into operation in the case in point. It is therefore safer to maintain them than to create an exception.

Finally, says Mr. Cooper to all young engineers, be content to go on as far as you can in the old ways, by old methods, and with the use of well-tried and common materials. No specification that was ever drafted would get good and proper materials and workmanship if left to itself, or placed in the hands of inexperienced or incompetent persons to execute or administer. A specification also, which contains any extra-refined, new, or severe demands which the aspiring engineer has not the proper experience, time, or assistance to enforce, is a mistake, for it means that the employer will have to pay for something that there is no guarantee of his getting. While, therefore, special works of importance may justify the employment of new methods and new materials, it must be recognised that this means extra inspection and supervision, and a higher run of prices than would be required for customary methods and materials. "Do not attempt to rush into new things until you have exhausted the capabilities of the things which are readily obtainable. For general classes of work you will find it better, both in time and money, to make use of the ordinary methods and those materials which are accessible." These remarks on specifications for engineering works deserve to be studied in every engineer's office in the world.

* Abstract from the *Journal of Gas Lighting*.

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RESULT OF TRIALS OF THE "TRUSTY" OIL ENGINE.

Trials have recently been made by Mr. Worby Beaumont of the "Trusty" oil engines of Messrs. Weyman and Hitchcock, Guildford. An engine of the following dimensions was used:—Diameter of cylinders, 7·37in.; length of stroke, 14in.; revolutions per minute, nominal, 248; diameter of fly-wheel, approximate, 5ft. The engine is of the vapouriser type, and works with the oils obtainable everywhere for lamp and other purposes, or with heavy oils. The vapouriser is a simple jacket cast with the separate extension of the cylinder like that common to gas engines. No trouble is experienced with anything in the nature of a deposit. Perfect combustion of the oil vapour produced takes place in the cylinder, leaving no deposit there, the exhaust being almost invisible on a dry day when working with a full load, and quite dry and free from oil in any form. The power of the engine was taken with a rope brake. The indicated horse-power was obtained from diagrams taken with a Tabor indicator. The number of misses, or of strokes made without combustible charge, was frequently taken, and the whole of the oil and water used was weighed.

The duration of the several trials was: Full power, 4 hours; half-power, 2 hours; running light, 1 hour. The intended full power load was 6 H.P., and the brake load was adjusted as nearly as possible to this. The running of the engine was very regular, and when at half-power the speed was within 0·4 of one per cent. that at full power. The oil used in the trials was Royal Daylight, costing in quantities about 4d. per gallon. Its specific gravity was found to be 0·802, one pint thus weighing 1·0025lb. The following is an abstract of the essential results of the trials:—

—	Full power.	Half-power.	Running light.
Brake horse-power	5·98	3·32	—
Indicated horse-power	7·04	5·48	2·72
Oil used per hour, lb	4·90	3·74	2·25
Oil used per B.H.P. per hour, lb.	0·82	1·12	—
Oil used per I.H.P. per hour, lb.	0·69	0·68	0·82

From the preceding figures it will be seen that the cost of working the engine with oil at 4d. per gallon on full-power load is about one third of a penny per indicated horse-power per hour.

In the "Trusty" engine, the ignition of the combustible charge in the cylinder is effected by means of the simple heated tube as commonly used in gas engines, the tube being heated by a lamp fed with oil of the same kind as that used in the engine. The quantity consumed for this purpose is very small, and was found to be 6oz. to 7oz. per hour. With average work the consumption under this head would be about 0·06lb. per indicated horse-power, and a cost per hour for full load of 6 H.P. of from one-sixth to one-fifth of a penny per hour. The total consumption of oil for working the engine on an ordinary full load, including that required for heating the ignition tube, will thus be 0·75lb. per indicated horse-power per hour, costing 0·375d.

The mechanical efficiency of the engine is very high, especially for engines of the four cycle class, and the absolute heat efficiency is very remarkably high.

CORRESPONDENCE.

ELECTRO-CHEMICAL EFFECTS DUE TO MAGNETISATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the *Engineer* of July 28th (Notes and Memoranda) I noticed an announcement of a series of investigations carried on by Lieut. George O. Squier, in the Laboratory of John Hopkins University on the above interesting subject.

I am glad Lieut. Squier has undertaken a research in this direction. I think it desirable, however, to state that he has not been the first to observe these effects of magnetisation. Several years ago I had the privilege of observing and investigating these obscure magnetic phenomena in a series of researches, the results of which were embodied in a number of Papers read before the Royal Society, London, under the title of "Electro-chemical Effects on Magnetising Iron," Parts I., II., III., IV., and which are published in the *Proceedings* of the Royal Society, 1887, 1888, 1889, and 1892 respectively.

I think I ought to mention this to prevent any question of priority arising, though at the same time I heartily congratulate Lieut. Squier on the results he has obtained, and wish him every success in his further investigations.—Yours, &c.,

THOS. ANDREWS, F.R.S.

Wortley Iron Works, near Sheffield,
August 8, 1893.

PAINT AS AN INSULATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to the statement of Sir Frederick Bramwell, that the paint on water pipes would act as an insulator, I may tell you that we have used for two years "Edison-compound" as a paint on our lead-covered branch lines, and that we find the use of such paint very effective in preventing corrosion and the early destruction of the lead covering. It may be observed that, to ensure durability, the painting has to be done several times, so as to give to the layer a certain uniformity and thickness. Unpainted lead is destroyed within a few years, whilst "compound"-coated cables do not show any signs of corrosion.—Yours, &c.,

ETIENNE DE FODOR,
Manager Athens Electric Central Station.

Athens,
July 26, 1893.

LEGAL INTELLIGENCE.

Marshall v. the South Staffordshire Tramways Company.

This case came before Mr. Justice Kekewich in the Chancery Division on Saturday last, and the following is abstracted from *The Times*:—

This was a motion by the defendant, Mr. William Somers Leo Schuster, for the removal of Mr. William James Carruthers Wain, who had been appointed in the action joint-receiver and manager of the defendant Company's undertaking on behalf of the plaintiffs, who were debenture-holders of the Company. Mr. Schuster had been added by the Court a defendant on behalf of debenture-holders, who did not agree that they were properly represented by the plaintiffs. Mr. Wain was Chairman of the defendant Company, and it was said he was interested in other companies, especially the Electric Construction Corporation, who had contracted to supply the defendant Company with electric traction upon terms which, it was stated, the Directors of the latter Company ought not to have entered into. It was accordingly alleged that Mr. Wain did not hold that independent position which, on behalf of the debenture-holders of the defendant Company, he ought to hold.

Mr. Justice KEKEWICH said the motion was entirely misconceived. Mr. Wain had been accepted both by the plaintiffs and by the defendant Company as receiver and manager. Mr. Wain was appointed by consent, and his lordship could not now decline to recognise the appointment, and, therefore, he would not interfere with him on that ground. There was one serious allegation, namely, with regard to Mr. Wain's connection with the Electric Construction Corporation. He was, and had been, closely connected with the Corporation, who were working the defendant Company's tramways under a contract which had been attacked. That contract did seem to his lordship, on looking at it, to be a contract of an extraordinary character, and it was quite right that this contract should be thoroughly investigated. It was desirable that the Court should have the assistance of an officer entirely unconnected with the Corporation, and that might have been a reason for not appointing Mr. Wain now to be a receiver and manager. It was too common for the office-bearers of one company to be connected with another company which was mixed up in business with the Company of which they were the office-bearers. It might be serious if Mr. Wain were standing alone as sole receiver and manager, uncontrolled except by his position as receiver and manager. In that case his lordship should have been inclined either to remove him or to associate with him some independent person, and not the less because he was connected with persons deeply interested in the success of these tramways. But this must be borne in mind, that Mr. Wain was associated with Mr. Sully, an accountant, whose duty it was to look after his colleague and see that the interests of the debenture holders were protected, and his conduct looked into. But there was a much more important matter than that. His lordship had before him Mr. Schuster, who was as hostile to the plaintiffs as could be, and was determined that neither Mr. Wain nor Mr. Sully should neglect their duty, and his lordship relied on Mr. Schuster taking care to see that Mr. Wain did not act in the interests of the shareholders of the defendant Company or of the Corporation. His Lordship did see that this contract with the Corporation required jealous investigation, and that the office of receiver and manager must be conducted with considerable care, and if, as the action proceeded, he saw the slightest reluctance on Mr. Wain's part or neglect of duty, he should not hesitate to remove him. The motion to remove him now upon the grounds which had been put forward was misconceived, and must be refused. There was not the slightest reason why the conduct of the action should be given to Mr. Schuster as had been asked. It was to the advantage of all concerned that he should be a watchful defendant, and left in the position of a cat watching a mouse. The motion must be refused. The plaintiffs would have their costs in any event. Mr. Wain would have no costs. The costs of the defendant company would be costs in the action.

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Hall v. Vaughan.

This case, which came before Mr. Justice Kennedy and a special jury at the Liverpool Assizes on Thursday of last week, was an action by the plaintiffs, Messrs. A. Hall and Co., Liverpool, against Mr. J. Vaughan, of Dolgelly, to recover £665 damages for breach of contract. Messrs. Hall and Co., the plaintiffs in the action, have supplied us with particulars of the action, of which the following is an abstract:—

Early in December last plaintiffs supplied an estimate for lighting defendant's mansion, which was accepted, the plaintiffs immediately preparing to execute the work, and contracting with other manufacturers for the turbine and generating plant. After a few weeks (it is alleged) the defendant, without consulting Messrs. Hall, appointed as his consulting engineer a gentlemen who is a competitor in trade. The plaintiffs advised the defendant that, having already undertaken the work and accepted all responsibility, they could not recognise the authority of any engineer, but were willing that defendant should have the installation examined and tested before accepting the same. The defendant, however, would not allow the plaintiffs to commence the erection of any part of the installation, and after some delay, during which the defendant sent inquiries for various particulars of the work, he finally refused to allow plaintiffs to carry out their contract. The plaintiffs, therefore, sued for damages, and when the case came on the defendant's counsel offered to compromise the matter by paying £450 and costs, and withdrawing any imputation upon plaintiffs' ability to carry out the work. This was accepted, and all litigation in the matter is now at an end.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The Gas and Lighting Committee of the Bolton Corporation announce in our advertisement columns that they are prepared to receive tenders for the supply and laying of high and low-tension mains. Specifications and forms of tender may be obtained from Mr. J. H. Rider, the Borough electrical engineer, and tenders must be sent to Mr. Alderman Miles, the Chairman of the Gas and Lighting Committee, not later than September 16th.

TENDERS ACCEPTED.—The Ealing Local Board have accepted the tender of Messrs. Neil, of Burdett-road, London, E., for the construction of the central station building, boiler house, &c., the amount being £7,963.

———The Markets and Gas Committee of the Blackpool Town Council have accepted the tender of the Brush Electrical Engineering Company (Limited), for lighting the new covered market by electricity.

——— The contract for the electric lighting of Liége has been ecured by the Compagnie Internationale d'Electricité, owners of the Pieper system.

APPOINTMENTS VACANT.—The Electricity Supply Company for Spain (Limited) require an assistant electrical engineer for their Madrid station. Some particulars appear in our advertisement columns, and applications must reach the Secretary, 15, St. Helen's-place, E.C., not later than the 15th inst.

APPOINTMENT.—Mr. E. T. Ruthven Murray has been elected borough electrical engineer by the Aberdeen Town Council.

PERSONAL —Mr. Stephen Sellon has joined the technical staff of the Electric Construction Company (Limited).

——— Mr. Johnson, of the Sheffield Electric Light and Power Company, sailed by the "Britannic" on Wednesday for New York *en route* for Chicago.

——— *London* this week gives a biographical sketch, with portrait, of Mr. Spencer Chadwick, the well-known auctioneer, in the course of which it says:—"In the electric lighting world Mr. Spencer Chadwick has had much to do ever since it came into practical use in London. From his designs and under his directions one of the first public installations, if not the first, was established in the Strand, now known as the Charing-cross and Strand Electricity Supply Corporation, of which company he is chairman. He is also chairman of two other electric lighting companies, and he is practically the sole owner of the Woking Electric Supply Company, now lighting a very large district."

BANKRUPTCY.—A first and final dividend of 3s. 4¾d. in the £ has been declared, payable at 15, Victoria-street, Liverpool, in the estate of Messrs. Cox, Robinson and Co., lately trading at 8, Strand-street, Liverpool, as electrical engineers. In the separate estates of the members composing the firm, Mr. Charles W. Cox and Mr. F. G. Robinson, first and final dividends have been declared of 4s. 3½d. and 8d. in the £ respectively.

LONDON METALLURGICAL COMPANY, LIMITED (IN LIQUIDATION).—The statement of affairs in this failure has been issued, and the estimated deficiency of assets to meet the liabilities of the Company (subject to cost of liquidation) is £1,936. 15s. 11d. The total liabilities expected to rank for dividend is £11,820. 18s. 1d., and the estimated amount available £9,884. 2s. 2d., showing the estimated deficiency as set out above. The first meeting of creditors will be held at the Inns of Court Hotel, Lincoln's Inn Fields, W.C., on the 15th inst. at 11 o'clock, and proofs must be lodged with the Official Receiver, 33, Carey-street, Lincoln's Inn, W.C., not later than 12 o'clock on the 14th inst.

LAW'S ELECTRICAL APPLIANCES COMPANY (LIMITED).—A meeting is called for September 6th, at 4 p.m., at Messrs. Davidson and Morriss's, 40 and 42, Queen Victoria-street, E.C., to receive an account of the winding up.

MESSRS. ERNEST SCOTT AND MOUNTAIN (LIMITED).—The contract for lighting the Heckmondwike Boot and Shoe Factory for the Co-Operative Wholesale Society of Manchester has been placed with this firm, as have also the lighting of the Leicester Co-Operative Society's premises and the Seaham Harbour Co-Operative Society's buildings.

MR. L. H. BLOOMFIELD.—We are informed that Mr. L. H. Bloomfield has been appointed agent for the "Excelsior" carbons, manufactured by Herr W. Grüdelbach, of Dinslaken-am-Rhein, Germany, and that he also represents several of the largest Continental makers of porcelain insulators, lamp holders, switches, and switchboards, measuring instruments, accumulators, &c. Mr. Bloomfield is also agent for Messrs. O. L. Kummer and Co., of Dresden.

MESSRS. SCHUCKERT AND CO.—The Chicago Exhibition catalogue of this firm of German electrical engineers contains a succinct account of the growth of their vast manufacturing business, and gives some very effective pictures of the exterior and shop-interiors of their works and of various central stations which they have equipped. The latter half of the catalogue is devoted to illustrated descriptions of the plant manufactured and supplied by Messrs. Schuckert and Co.

MASCHINENFABRIK OERLIKON.—We have received two illustrated pamphlets from the Maschinenfabrik Oerlikon describing their machinery for the transmission of electric power. One of these *brochures* deals with the Drehstrom system, giving tabulated data of the generators, motors, and transformer plant; and the second contains particulars of continuous-current dynamos, motors, and regulating apparatus, and also of a lathe which is designed to be driven by an electromotor and worm gear, the motor being built on to the side of the lathe bed.

COOKING BY ELECTRICITY.—An exhibition of electric cooking apparatus was given on Friday at the offices of the Manchester Edison Swan Company (Limited), when a dinner of five courses was cooked by electricity in the presence of a number of guests, who watched the process with great interest. We understand that Mr. Fawcus, the manager of the Company, is receiving a large number of orders for the installation of cooking apparatus in the district.

MONEY-SAVING APPLIANCES.—Messrs. Wells and Co. send us their new list of waste oil filters, oil feeders, lamps for engine tenders, file handles, oil bottles, soldering lamps, &c. The various appliances manufactured by this firm are in use in the chief Government departments, and a claim is made that more than a million are in use all over the world.

ELECTRIC COAL-CUTTING MACHINERY.—The dispute in the coal trade is bringing into prominence the question of the introduction of electric coal-cutting machinery in the mines in the Midland district.

ELECTRIC LOCOMOTION ON ROADS.—Mr. W. Ballantyne, President of the Road Surveyors' Association, speaking at the annual meeting of the Association recently held at Edinburgh, gave a history of the roads in this country, and said that the Roads and Bridges Act had been productive of a large amount of good. If electricity were applied to locomotion it was probable that some of the traffic over the railways would be transferred to the roads.

"ELECTRICITY IN THE SERVICE OF MAN."—Part XI. of "Electricity in the Service of Man," now being published by Messrs. Cassell and Co. in 15 monthly parts, is just issued, and deals with transformers, electric meters, electric motors, electric railways, and tramways. The work is very fully illustrated.

ABERDEEN.—The Gas Committee of the Town Council have resolved to recommend that the price for the supply of electricity for light to private consumers be fixed at 7d. per Board of Trade unit.

AMBLESIDE (WESTMORELAND).—The Holloway Electricity Supply Company (Limited) have informed the Local Board that they intend applying for a Provisional Order for the Ambleside district.

BELFAST.—The Corporation have, subject to evidence of title, accepted a site in Chapel-lane for an electric light station.

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BRENTFORD.—The Board of Guardians have requested their Schools and House Committees to consider the question of lighting the schools and workhouse, with special reference to the possibility of introducing the electric light.

BRISTOL.—At the meeting of the Electrical Committee on Thursday last week, it was stated that owing to the non-delivery of some of the plant some slight delay would take place in connection with the general lighting of the city, although the arrangements for lighting the forthcoming Industrial Exhibition would not be interfered with. Numerous applications had been sent in for the appointments about to be made by the Committee, and the Resident Engineer was making inquiries preparatory to making final selections.

CANTERBURY.—The Town Council at their last meeting approved the recommendation of the Electric Lighting Committee that their Provisional Order, obtained in 1891, should be transferred to the Canterbury Electricity Supply Company (Limited).

CHELTENHAM.—At the meeting of the Town Council on Tuesday the recommendation of the Electric Lighting Committee that Mr. Preece's report be carried out, advising the adoption of the high-pressure alternating-current system of electric lighting for the town, was agreed to.

CHESTERFIELD.—At the last meeting of the Town Council it was reported by the Electric Lighting Committee that until replies have been received from persons residing within the "trade area" as to the quantity of electric current they would require, nothing further could be done in the matter. When these replies were received, they would be laid before the Council. The Council decided to give notice to the National Telephone Company, requiring them to remove all their poles now standing in the streets and thoroughfares, and to lay the wires underground.

FAREHAM.—It will be remembered that at a recent meeting of the Local Board the motion for adopting the contract with the Electric Lighting Company for supplying light for the streets was not carried; there were an equal number of members voting for and against, and the Chairman declined to give a casting vote. The question came up again at the meeting of the Board on Friday last, when the Clerk read the proposed contract, which had been slightly amended, the penalties for insufficient lighting being reduced from 3d. to 1½d. per hour for arc lights, and ½d. per hour for incandescent lights. Under the contract the Company agree to supply 20 arc lamps of 1,200 nominal c.p. each, and 92 incandescent lamps of 20 nominal c.p. each, for the sum of £549 per annum, for a period of three years, the contract to be terminable by six months' notice if the light did not reach the proper standard. A long discussion ensued, and the motion for passing the contract was ultimately carried by a small majority.

ECCLES.—The Electric Lighting Order, promoted by the Town Council, has received the Royal assent.

HOVE.—A Local Government Board inquiry was held at the Town Hall last week, to consider an application by the Commissioners for sanction to borrow £1,400 for the purpose of lighting by electricity the Town Hall and public offices.

ISLINGTON.—The Bill introduced for the formation of the Islington Electric Lighting Order has received the Royal assent.

KEIGHLEY.—The Town Council on Tuesday had again before them the question of electric lighting. The Gas Committee recommended that borrowing powers to the extent of £30,000 for gas works extension purposes be applied for, and, whilst the recommendation was adopted, it was stated that the Committee were carefully watching the experiments that were being made in other places with respect to the supply of the electric light.

LEAVESDEN.—The St. Pancras Parish Schools at Leavesden are to be lighted by electricity. Sufficient power for driving the dynamos can be obtained from the existing machinery.

MERTHYR.—At the last meeting of the Local Board the clerk read some letters he had received from Birmingham in regard to the cost, &c., of electric lighting, and inviting the Board to inspect the plant. It was, however, thought that installations at places nearer home would be more suitable, and the clerk was instructed to communicate with the local authority at Pontypool.

NEWCASTLE-UPON-TYNE.—The City Lighting Committee have decided to request the Watch Committee to take into consideration the advisability of taking over the electric lighting of the city generally.

OBAN.—The Caledonian Electric Supply Company (Limited) intend applying for a Provisional Order empowering them to supply electricity within the Oban district.

SHOREDITCH.—The Vestry, at their meeting last week, resumed the debate on the question of the purchase of the Pitfield-street site. After some discussion an amendment to the recommendation of the Electric Lighting Committee that a special meeting of the Vestry be called to consider the matter was carried, but a further amendment was moved that no action be taken until a financial report be made by the various bodies concerned on the scheme, and the debate on this was not finished when the Vestry adjourned.

STAFFORD.—The Town Council have adopted the recommendation of the Electric Lighting Committee to apply to the Local Government Board for permission to borrow £20,000, for the purpose of installing the electric light in the borough in accordance with the scheme prepared by Dr. John Hopkinson, who suggested the adoption of a continuous-current, low-tension system with accumulators, and the three-wire system of distribution. Dr. Hopkinson was of opinion that the electric light could be supplied at a profit with 1,500 to 2,000 lamps, and the borough engineer said that customers had already been found for 1,500 lamps at 7d. per unit.

PATENT RECORD

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

July 8, 1893.

13,340. H. H. LAKE. London. Improvements in, or relating to, electric furnaces. (Adam Charles Girard and Ernest Auguste, Georges-street, France.)

13,341. R. NIEWERTH. London. Improvements in transforming electrical energy of high tension into low tension, and in apparatus therefor.

July 10, 1893.

1,353. H. O. BODEN. Manchester. A new or improved means of automatically regulating the brushes of dynamo-electric machines.

July 11, 1893.

13,403. J. H. MASON and A. V. DERWERKEN. London. Improvements in electric batteries.*

13,412. E. CONRADY. Keighley. Improvements in automatic regulators for electric generators.

13,448. F. H. ASCHNER. Liverpool. Improvements connected with or relating to meters or instruments for measuring electricity.*

13,469. F. B. ASPINALL. London. Improvements in electric railway signals.

13,489. B. ZEITSCHEL. London. An improved electric bell.*

July 12, 1893.

13,507. A. BARR and W. STRAND. Glasgow. Improvements in range finders, and in electrical appliances for transmitting the indications of the same to a distance.

13,533. C. D'OYLEY AUTCHINS. Feltham Hill. Safety insulated clip for extracting and replacing electric fuses.

13,551. H. E. NEWTON. London. The production of aromatic amido compounds by means of electrolysis. (The Farbenfabriken vormals, Friedrich Bayer and Co., Germany.)

13,552. A. D. and F. M. LEWIS. London. Improvements in electric arc lamps.

13,568. C. T. J. VAUTIN. London. An improved dry electrolytical process for the production of an alloy of lead and sodium or potassium.

July 13, 1893.

13,610. A. I. GRAVIER. London. Improvements in dynamo-electric machines.

13,663. H. WUBBELER. London. An improved electric clock.

13,644. E. MAGNIN. London. Improvements in or relating to telegraphic type-printing apparatus.

13,647. C. L. R. E. MENGES. London. Improvements relating to galvanometers.

July 14, 1893.

13,672. A. B. BROWN and W. F. KING. Glasgow. Improvements in apparatus for transmitting telegraphic indicating and other analogous signals or movements by means of electric currents.

13,723. C. KELLNER. London. Apparatus for the electrolytic production of bleaching liquid.

July 15, 1893.

13,730. CROGGON AND CO. (LIMITED). London. Improvements in connecting to zinc rods of Leclanché or other galvanic batteries.

13,749. M. H. SMITH. London. Improved means of working and controlling electric elevators.

13,773. S. A. HUNTER. London. Improvements in arc lamps.

13,774. E. SPRATT. London. A means of maintaining the human body in electrical connection with the earth.*

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13,779. J. J. Moller. London. Improvements in telephone circuits.
13,792. J. J. P. Clariot. London. Fluid operated electric switches.

July 17, 1893.

13,858. A. Heil. London. A galvanic element.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

13,297. Horn (Mears and another). Electropathic appliances.
13,702. Ruskas. Telephonic system for transmitting news.
14,181. Shrewsbury and Dobell. Electric batteries.
16,124. Bennet. Telephonic switching apparatus.

1893.

7,387. Thompson (Coffin). Electrically-welding metals.
9,304. Boult (Waring). Electric incandescent lamps.
9,779. Allison (Electric Specialty Company). Electric switches.
10,205. F. L. and L. H. Dyer. Electric steering gear.
10,207. Siebold. Arc lamp electrodes.
10,963. Clark. Electro-mechanical switch, &c.
11,092. Hellesen. Electric batteries.
11,105. Craney. Electrolytic apparatus.
11,106. Craney. Electrolytic cells.
11,107. Craney. Electrolytic apparatus.
11,108. Craney. Electrolysis of salts.

COMPANIES' MEETINGS AND REPORTS.

Liverpool Overhead Railway Company.

The tenth half-yearly general meeting of the proprietors of this Company was held on Wednesday, at the Law Association Rooms, Cook-street, Liverpool, Sir William B. Forwood presiding.

The Directors' report (which appeared in our last issue) and statement of accounts having been taken as read,

The CHAIRMAN said: Gentlemen, it affords your Directors very great satisfaction to meet you on this the first annual meeting after the completion of our overhead railway. This feeling of satisfaction is very much increased by the fact that the railway, both in its construction and in its electrical equipment, has been most successfully carried out. Very rarely indeed has an undertaking of such magnitude, involving so many considerations of the highest scientific importance, been so successfully inaugurated. From the first week after the railway was opened for public traffic we have maintained a regular and reliable quick service of trains; and to-day, although we are running a five minutes' service, 94 per cent. of our trains are on time, and of the remaining 6 per cent. 3 per cent. are irregular only to the extent of a few seconds. Yesterday we ran a 3½ minutes service without a hitch. For this excellent result we are indebted to the skill of our engineers, Sir Douglas Fox and Mr. Greathead, whom I am glad to see here to-day, and last, though by no means least, to the attention and care of our general manager and engineer, Mr. Cotterell. Your Directors only modestly claim credit for having insisted upon having first-class work, both in the construction and equipment of the railway, and also in having everything thoroughly and carefully tested before opening the line for traffic. The accounts presented to you to-day embrace a period of rather more than 16 weeks; we carried during that period 1,370,742 passengers, or at the rate of 4,300,000 per annum. It is estimated that the penny omnibuses at present running in competition with the railway are carrying at the rate of 2,000,000 passengers per annum, thus making the traffic already developed along the line of docks more than 6,000,000 passengers per annum; and this during a time of great commercial depression, when the shipping trade of the port has been paralysed. This depression has affected the railway in a curious way. Usually the roadway fringing the docks is so blocked with carts and lorries conveying merchandise as to make quick vehicular traffic impossible. At present the goods traffic is so light that the omnibuses have been able to make very fair running time. This, coupled with the extraordinarily fine weather, has no doubt given them a larger proportion of the passengers than will, with ordinary conditions, fall to them. We are every day developing new sources of traffic. A ride upon the Electric Overhead Railway has become an important item in the programme of every well-conducted excursion, and although our present Northern terminus is nearly a mile away from the Seaforth shore, we carry large numbers destined for Seaforth. This induces your Directors to expect a large increase of traffic on completion of the Northern extension. While we are thus engaged in endeavouring to increase the number of our travellers we are not unmindful of making such economies in our working expenses as may be practicable, having due regard to the efficiency of the service. Electrical traction, combined with automatic electric signals and lighting, should make a very cheaply-worked line; and we believe when we take the electrical generating station into our own hands we shall effect a considerable saving. But we have, however, never regretted having placed this part of our system in the hands of the Electric Construction Corporation to work for us until it had been thoroughly tested. You will notice that the result of our sixteen weeks' working has been that, after paying all expenses, rates, and taxes, and general charges, there is a balance to the credit of net revenue account of £5,361. 15s.; deducting from this interest on Debentures and the dividend due on our Preference capital we are left with a balance of £3,293. 9s. This is equal to about 2½ per cent. on our Ordinary capital for the time we have been at work. Your Directors recommend that the balance be carried forward. The amount of share capital issued is £450,000. and of Debenture stock £125,000. This your Directors estimated would complete the railway, including the Northern extension to Seaforth, but we find we have to provide about £11,000 to settle the contractor's bill of extras, and a further amount for new stations. We also consider we ought to have a sum in hand as working capital to provide for these items. We to-day, at a special meeting, intend asking you for power to issue the remainder of the Preference capital. We shall, of course, only issue such an amount as may be necessary; we are unable at present to define the amount, as a good deal depends upon the settlement of our accounts with the Dock Board. These accounts are now in course of adjustment. The Northern extension is being proceeded with, and should be completed by the end of the year. In conclusion, I have only to repeat what I have said before, that in the Overhead Railway we have a very valuable property, with a sure and, I think, rapidly progressive future. There have been many in Liverpool who have been sceptical as to the extent of our traffic, and the estimate we put forward in our prospectus of 5,000,000 passengers per annum was deemed extravagant. We have only been running for four months, yet we see a total traffic developed of over 6,000,000 per annum. It is the old, old story: give rapid, frequent, and cheap means of travel through a populous place, and you cannot fail to create an unlooked-for and unexpected amount of travel. These conditions exist on our railway, and I feel certain you will not be disappointed. No one who has witnessed the marvellous development of local travel which has followed the opening of the Overhead Railway in New York can doubt that a similar development will take place on the Liverpool Overhead Railway. We are not so fully supported by our merchants and shipowners as we had a right to expect, for the railway was mainly constructed for their convenience and to enable them to economise in their working expenses. Cotton porters, ship people, and passengers still largely use the 'buses, though the loss of time in doing so is very considerable. I think we may fairly ask the mercantile public to take a little trouble to see that their workpeople make use of the railway. We have also introduced cheap workmen's return tickets. Return tickets for 2d. are now issued up to 8 a.m., which are available for return during any hour of the day. We shall consider further concessions in this direction. We see our way to a considerable increase of our excursion traffic next year, and we are every day drawing more and more passengers from those parts of Bootle and Toxteth park in proximity to the railway. The Chairman concluded by moving the adoption of the report and the statement of accounts.

Mr. R. HOBSON seconded, and the motion was carried.

On the motion of the CHAIRMAN, seconded by Mr. R. HOBSON, a dividend of 5 per cent. per annum upon the Preference shares of the Company was declared.

This concluded the business of the ordinary meeting, and it was now resolved into a special one according to notice given.

The CHAIRMAN said the object had already been explained to them, and he simply moved:—

"*That the Directors be and they are hereby authorised to issue four thousand five hundred Preference shares of £10 each (being the unissued portion of the twelve thousand Preference shares of £10 each, bearing interest at the rate of £5 per centum per annum, created by the Company on January 10, 1893) in such amounts and manner, at such times and on such terms, as they may think fit.*"

Mr. HOBSON seconded, and the resolution was carried unanimously.

Mr. STEVENSON, a shareholder, inquired when it was intended to extend the railway southward.

The CHAIRMAN said they had parliamentary powers to carry the line southward, so as to effect a junction with the Cheshire Lines Railway, and if they exercised these powers they would tap a large traffic. They had pledged themselves to the shareholders that they would obtain their sanction before proceeding with the extension, and that pledge they would carry out. At present the Directors thought that it would be better for them to develop the present line before fully undertaking that extension.

Another SHAREHOLDER asked if it was the intention of the Directors to allot the new issue of Preference stock among the Ordinary shareholders.

The CHAIRMAN said the subject would be carefully considered by the Board, and he hoped that the Ordinary shareholders would obtain the bulk of the new stock.

A vote of thanks to the Chairman and Directors brought the meeting to a close.

Oxford Electric Company (Limited).

The ordinary general meeting of the shareholders of this Company was held on Friday at the offices, 45, Broad-street, Oxford.

The CHAIRMAN (Sir Henry Mance, C.I.E.), in moving the adoption of the report and accounts for the last year, said: Since we have commenced work the Directors have been aiming to effect three things—first, to increase the revenue; secondly, to decrease the expenses; and, thirdly, to render the system by which we generate and supply current as economical and perfect as possible. With regard to revenue, although that for the first week was less than one sovereign, it steadily increased during the six months, the best week's receipts being £86. The number of customers has increased to 70, that is, counting the colleges as one only, notwithstanding some of them have several hundred lights. We have at

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present an equivalent of 5,060 8 c.p. lamps installed. With regard to reduction in expenses, we have thought it desirable to remove the management from London. Mr. George Offor, our late manager, had been associated with this Company from its inception, and although he is now devoting himself to the development of the Crystal Palace District Electric Supply Company, I am quite sure that if we required his good offices again his friendly services would always be at our disposal. No one can appreciate more than I do the value of work which invariably has to be carried out in connection with the formation of a company of this kind, and I ought not to allow this opportunity to pass without expressing my thanks to Mr. Offor. It was, however, felt that when once fairly launched the management of the Oxford Company might safely be left to local staff. Mr. J. H. McLean has been appointed our engineer in charge, and Mr. H. Eeles our local secretary. We have ceased to pay rent for our London office, and these changes have resulted in considerable economy, without, I may say, impairing efficiency. With regard to our system, which I believe is worked with fewer interruptions or fewer difficulties than any installation of similar size in the country, we have been able, by the use of a supplementary transformer, to charge our batteries with much greater economy. We have also introduced improvements in the automatic switch used at the sub-stations, and Mr. McLean has designed a very ingenious apparatus which, suspended inside the arc light lamp-post, puts out the lamps at any required hour, thus dispensing with the necessity for sending an attendant round during the night. On December 31st the length of trench work done amounted to about 6,500 yards, containing 12,000 yards of Callender's low-tension mains, and 10,500 yards of the Silvertown high-tension india-rubber cables. The whole of this is in as perfect order as when laid. With regard to future prospects, the engineer in his last report anticipated that by the beginning of October we should have an additional 2,000 lights. The Directors have under consideration the introduction of a sliding scale of charges, which will lessen the cost of current and benefit not only the large consumers, but those who, having only a small number of lights, use them continuously.

Ald. BUCKELL, having seconded the proposition, the report and balance-sheet were unanimously adopted.

Mr. W. S. Carver was then appointed auditor, and the proceedings terminated.

Cuba Submarine Telegraph Company (Limited).

The following is the report of the Directors for the half-year ended June 30th, to be presented at the forty-fourth ordinary general meeting of shareholders, to be held at the Company's offices, 58, Old Broad-street, E.C., on Wednesday next, at 12 noon :—

The gross receipts for the half-year (including the balance brought from last account) amount to £25,151. 15s. 11d., and the gross expenditure to £6,749. 8s. 5d., leaving a sum of £18,402. 7s. 6d. to the credit of revenue account. Of this the sum of £1,500 has been set aside as a reserve against any loss from the deposits with banks, and £5,500 added to the reserve fund, making that fund £100,000. The dividend on the Preference shares will absorb £3,000, and leave £8,402. 7s. 6d., out of which the Directors recommend the payment of a dividend on the Ordinary shares at the rate of 8 per cent. per annum, free of income tax, the balance, £2,002. 7s. 6d., being carried forward to the current half-year's account. In view of the probable reduction of rates at no very distant date, the Board has determined to carry forward a larger balance than usual, towards meeting any diminution of the net income during the earlier period of the change.

The main cables have continued in good order throughout the half-year, with the exception of the Batabano-Cienfuegos 1870 cable, which underwent some repairs in March. The cost of these and of the New Harbour lengths, referred to in the last report, appear in the present accounts.

No decision has yet been given in the Company's suit against the Spanish Government at Madrid, but efforts are being made to bring the case to a conclusion.

The Director who retires from the Board at this time is Mr. George Keith, who, being eligible, offers himself for re-election. Mr. John Gane, the auditor, also retires, and is eligible for re-election.

Birmingham Central Tramways Company (Limited).

The report of the Directors of this Company, which is to be submitted at the meeting to be held at the Queen's Hotel, Birmingham, on Wednesday, the 16th inst., at 12:30 o'clock, states that the decrease of working expenses and increase of working profits is shown in the following comparative statement :—

Year ended June 30	Miles run.	Passengers carried.	Traffic receipts, &c.	Working expenses.	Working profits.
			£ s. d.	£ s. d.	£ s. d.
1892...	2,657,145	25,718,282	152,238 15 2	116,210 13 5	37,028 1 9
1893...	2,655,802	26,277,089	154,684 5 3	111,230 4 10	43,454 0 10

The revenue account shows a balance of £24,216. 8s. 1d., which, with £13,921. 18s. 8d. brought forward, makes £38,138. 6s. 9d. The Directors recommend—

(1) That £20,000 be placed to reserve account against depreciation.

(2) That the payment of the dividend on the Five per Cent. Guaranteed shares, amounting to £5,000, be confirmed.

(3) That a dividend of 2½ per cent. for the year ending June 30th be declared on the Ordinary shares, amounting to £9,700 ; and

(4) That the balance of £3,438. 6s. 9d. be carried forward.

The balance of £9,302. 18s. 4d. due to the bankers on June 30, 1892, has been repaid, and on June 30, 1893, the bankers held the sum of £8,623. 9s. 5d. to the credit of the Company. The auditors' special certificate states that the Company have Debentures to the amount of £18,000 available for issue, and that the reserve fund is invested in the most legitimate manner in the development of the resources of the Company.

The present Directors retire, and offer themselves for re-election. Messrs. B. J. Round and J. Booth, of Birmingham, substantial shareholders in this Company, submit themselves as additional Directors. The present Directors trust that the nomination of these very representative shareholders may be cordially supported. Upon the representation that his retirement at the present time would be detrimental to the interest of the Company, Mr. Ebbsmith submits himself for election as a Director for the ensuing year, on condition that he will be permitted to retire from the chair. The auditors (Messrs. Howard Smith, Slocombe, and Co.) retire, and seek re-election as auditors of the Company.

The working accounts for the twelve months accompany the Directors' report. The tramways are worked by steam, horses, cable, and electricity, and the receipts for the electrical cars show a small loss of rather less than £100. The total miles run by the electrical cars for the period was 140,993, and the passengers carried 1,257,399.

NEW COMPANIES, STATUTORY RETURNS, &c.

In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1893, pages 320-348, *&c., &c.*]

LANE FOX ELECTRICAL COMPANY (LIMITED).—Mr. St. George Lane Fox, the Chairman of the Directors, notifies the Registrar of Joint-Stock Companies that there have been no transactions of any kind to record, and the Company has practically ceased to exist and will shortly be wound up in proper form, as the purposes for which it was registered were not proceeded with. Nothing whatever has been called on any of the shares, and no property has been transferred to the Company.

LONDON AND LANCASHIRE ELECTRIC AND GENERAL ENGINEERING COMPANY (LIMITED).—The statutory return of this Company, made up to July 11th, has been filed. The nominal capital is £20,000, in £5 shares, of which 1,786 have been taken up. 1,000 shares have been issued as fully paid while £2 per share has been called and paid on the remaining 786 shares, resulting in the payment of £1,146, and leaving £426 in arrears.

CITY NOTES, &c.

CALLS DUE.—*August* 15 : CITY OF LONDON ELECTRIC LIGHTING COMPANY, £3 per share on £20.000 Six per Cent. Cumulative Preference £10 shares (this sum includes £1 per share premium) ; ELMORE'S GERMAN AND AUSTRO-HUNGARIAN METAL COMPANY, 25 per cent. on £5,000 Ten per Cent. First Mortgage Debenture stock.——*August* 31 : NATIONAL TELEPHONE COMPANY, £25 on £273,523 Four and a-Half per Cent. Debenture stock.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended August 6th were £801, as against £919 for the corresponding period of last year, being a decrease of £118. The total receipts for the half-year amount to £4,226, against £3,940 in the corresponding period of 1892, being an increase of £286.

DIRECT SPANISH TELEGRAPH COMPANY.—The gross receipts for the month of July were £1,656, as compared with £1,684 for the corresponding period of last year.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this Company for July amounted to £24,000, and from January 1st to July 31st to £156,800. In the corresponding months of 1891 and 1892 the amounts were £152,000 and £165,800 respectively.

SALT LAKE AND OGDEN GAS AND ELECTRIC LIGHT COMPANY (LIMITED).—A prospectus is issued of this Company, which, under the auspices of the Gas, Water, and General Investment Trust (Limited), offers for subscription $1,250,000 Six per Cent. First Mortgage Bonds at £205 per $1,000 bond, payable £20 on application and £185 on allotment. The Company is incorporated under the laws of Utah, U.S.A. It is difficult to understand why subscriptions are invited from the British public, as hitherto the management of the concern appears to have been in American hands ; but (the prospectus states) to secure continued efficient management of the properties, an English Company has been formed in which the control of the American Company will be vested, and the Directors of this English Company are Directors of the Gas, Water, and General Investment Trust (Limited). The English market will probably find other outlets for its superfluous capital. There are many electrical undertakings at home languishing for financial support, several of which appear much more likely to result satisfactorily. The list of applications closes on Saturday, the 12th inst., for London, and Monday, the 14th, for the country.

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WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended August 4, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,984.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the two weeks ended July 31st were £1,778, as compared with £2,023 for the corresponding period of last year.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Aug. 2.	Price Wednesday, Aug. 9.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 9. Highest	Lowest.
			TELEGRAPHS			£ s. d.			
£1,134,640	Stock	12/6	Anglo-American xd	48½ 49½	49 50	5 10 0	Jan. Apr., July, Oct.	48½	..
£2,932,680	Stock	25/0	Do. Preferred xd	91½ 92½	92 93	5 18 3	" "	92⅝	92⅝
£2,932,680	Stock	5/0	Do. Deferred	9 9½	9½ 10	.. ..	.. ..	9½	9½
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer) ..	99 102	99 102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	11⅜ 12½	11⅜ 12½	5 6 1	Mar., June, Oct., Dec.	12⅛	11⅜
£36,400	£100	5%	Do. 5 per Cent. Bonds x	99 103	99 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107 111	107 111	4 10 1	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	..	120 130	5 7 8	April and October..	..	..
16,000	10	8/0	Cuba Submarine	11½ 12½	11½ 12½	6 8 0	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	18½ 19½	18½ 19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½ 3½	2½ 3½	4 11 5	April and October..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9 10	9 10	5 0 0	" "	9⅞	9½
60,710	20	3/6	Direct United States	11⅜ 12	11⅜ 12	5 16 8	Jan., Apr., July, Oct.	12	11⅜
400,000	10	5/6	Eastern xd	14⅜ 15	14⅜ 15	4 6 8	" "	15	14½
70,000	10	6%	Do. 6 per Cent. Preference xd	16½ 16⅞	16½ 16⅞	3 11 8	" "	16⅞	..
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock.....	112 115	112 115	3 9 7	May and November	..	..
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899 ..... xd	106 109	106 109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15½ 15⅝	15½ 15⅝	4 11 1	Jan., Apr., July, Oct.	15⅝	15½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock ..... xd	111 114	111 114	3 10 2	February & August	..	..
£70,600	100	5%	Do. 5 p. c.(Austln. Gov. Sub.) Debs 1900....	102 105	102 105	4 15 3	January and July ..	..	..
£.08,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb.,1900 ..	101 104	101 104	4 16 2	" "	102¼	101¼
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.) xd	101 104	101 104	3 16 11	February & August	..	..
£.00,000	£25	..	Do. 4% Mauritius Sub. Debs.	1 3½ 103½	103½ 103⅝	.. ..	May and November	..	..
180,227	10	4/0	Globe Telegraph and Trust xd	9⅜ 9½	9⅜ 9⅝	4 13 8	Jan., Apr., July, Oct.	9⅝	9⅜
180,042	10	6%	Do. 6 per Cent. Preference xd	15½ 15⅝	15½ 15⅝	3 18 2	" "	15¼	..
150,000	10	5/0	Great Northern	19½ 20	19½ 20	4 5 0	Jan., April, and July	..	..
£.00,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105 108	105 108	4 12 7	March & September	107	..
17,000	25	37/6	Indo-European	39 42	39 42	5 19 1	May and November	40½	39½
37,548	10	4/0	London Platino-Brazilian	4 5	4 6	3 6 8	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs. ..	100 103	100 103	3 17 8	.. ..	..	..
11,802	8	4/0	Reuter's	4½ 5½	4½ 5½	.. ..	April and October..	..	..
3,381	£100 Cert.	30.0	Submarine Cables Trust 6 per Cent.	116 121	115 120	5 0 0	" "	..	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July ..	..	..
£60,900	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	3 4	2½ 3½	.. ..	January and July ..	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	97 101	97 101	7 18 5	June and December	..	..
88,321	10	6d.	West India and Panama	1½ 1⅝	1 1½	.. ..	.. ..	1½	1 1/16
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 11	10½ 10⅝	5 11 7	May and November	10⅝	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	105 108	105 108	4 12 7	June and December	107½	..
64,242	15	4/6	Western and Brazilian	7 7½	6⅞ 7½	5 3 8	May and November	..	..
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5⅞ 6½	5⅞ 6½	.. ..	.. ..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1½ 2	1½ 1¾	.. ..	.. ..	1⅞	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910 xd	103 106	103 106	5 13 2	February & August	..	..
£252,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 191(xd	103 106	103 106	5 13 2	" "	104½	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120 125	120 125	5 12 0	May and November	..	..
£ 69,000	£100	6%	Do 6 per Cent. Sterling Bonds	100 103	101 104	5 15 5	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	2 3	2 3	.. ..	.. ..	2⅛	2⅛
22,,,,00	14/0	3½d.	Consolidated Telephone Const. & Maintenance ..	½ ½	½ ½	.. ..	May and November	..	..
20,000	£1	4½d.	Oriental (11s. paid)	½ ½	½ ½	7 18 2	Yearly	..	..
488 867	5	2/6	National xd	4½ 4⅝	4½ 4⅝	5 5 3	June and December	4⅝	4½
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref. xd	14½ 15	14½ 15½	3 17 5	" "	15½	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid) xd	14 14½	14 14½	4 2 9	" "	14½	..
90,950	5	2/0	Do. 5% Non-Cumulative 3rd Pref. ..... xd	5½ 5½	5½ 5⅝	4 10 11	.. ..	5 7/16	5⅛
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid) ..	111 113	110 113	3 19 8	January and July ..	112⅝	110½
68,000	5	1/0	United River Plate	2 2½	2 2½	.. ..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	10¾ 11½	10¾ 11½	..	—	10¾	..
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid) ..	12½ 13	12½ 13	..	—	12⅝	12⅛
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	—	—	—
£150,000	£5	..	Electricity Supply Company Ordinary	... ..	.. ..	..	—	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	—	...	..
8,322	£5	..	House to House Electric	.. ..	.. ..	..	—	—	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	.. ..	.. ..	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	—	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4 7/16 4 7/16	4 7/16 4 7/16	..	—	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6½ 6⅝	6½ 6⅝	..	—	..	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	—	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	5½ 6½	5½ 6½	3 4 0	—	..	..
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102 105	102 105	4 15 3	June and December	..	..
6,452	£10	..	Notting Hill Electric	5 6	5 6	—	—	—	—
19,980	£5	9½%	St. James' and Pall Mall	6½ 6⅝	6½ 6⅝	..	—	6⅝	..
50,000	£5	7%	Do. 7 per Cent. Preference xd	7⅝ 8½	7⅝ 8½	4 4 10	—	8⅝	..
59,900	5	1/6	Westminster Electric Supply (fully paid) xd	5 5½	5 5½	3 3 8	—	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/6	Brush Electrical Engineering	3 3½	3½ 3⅝	..	—	3½	3½
75,000	2	6%	Do. 6 per Cent. Preference	2 2½	2⅝ 2⅝	5 1 1	—	2⅝	2⅝
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107 109	107 109	4 2 7	March & September	108¼	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Cumulative Pref..	4¾ 5½	4¾ 5½	6 1 9	January and July —	..	..
12,139	5	..	Edison and Swan United	.. ..	.. ..	—	—	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid) ..	.. ..	.. ..	..	—	..	..
49,900	10	12/0	Electric Construction	1½ 2	1½ 2	..	—	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	¼ ½	¼ ½	—	—	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	—	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22⅝	21½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	1½ 2½	1½ 2½	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	4/0 5/0	4/0 5/0	..	—	—	..
78,949	5	1/9	Swan United (£3. 10s. paid)	2 2½	2 2½	14 11 6	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance .... xd	33 35	33 35	5 2 10	March and July.....	34½	33½
£150,000	100	5%	Do. 5 per Cent. Bonds, red.1894	101 104	101 104	4 16 2	January and July —	103½	102
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)..	.. ..	.. ..	—	—	—	—
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	—	—	—	—
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	5%	City and South London Railway	35 37	35 37	1 13 9	May and November	..	—
37,500	£10	£10	Liverpool Overhead Railway	4⅜ 4⅝	4½ 4¾	—	" "	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 796.—Vol. XXXI. FRIDAY, AUGUST 18, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

We have received a report of the interview between the Gas and Electricity Supply Committee of the Bradford Town Council and Lord Kelvin. As was stated in a note four weeks ago, the time has come when an extension of the municipal supply in this town is necessary, and the Corporation having become aware that their two-wire system was quite antiquated, have received reports from Mr. Shoolbred, who to show that he was quite up to date suggested a five-wire scheme with automatic contrivances at the ends of the feeders for maintaining a constant voltage, and another from their engineer, Mr. Baynes, to whom so much credit is due for the success of the undertaking, and who is well competent to advise on the case. As these reports to some extent conflicted, Lord Kelvin was asked to adjudicate thereon. Some men would have given an opinion as a Q.C. would do, without rising from his chair after perusing the documents. Not so Lord Kelvin. He visited Bradford, examined the works, investigated the probable requirements of the town, and attended a meeting at which both Mr. Shoolbred and Mr. Baynes were present, and submitted to a volley of questions for about three hours. No higher tribute could be paid to his versatility than the variety of the questions which it was thought suitable to put to him. The comparative merits were discussed of two, three, and five wires; of Willans and Corliss; of accumulators and gas engines; of 180lb. steam or 140lb.; boilers upstairs or downstairs; Lancashire or Babcock-Wilcox; cables or culverts; the propensities of Bradford rats; "if we get 90 per cent. of energy from the dynamos, where does the other 10 per cent. go to?" To all these and many further questions Lord Kelvin gave ready and simple replies, and, had time permitted, he would no doubt have advised with equal gravity as to whether brown or green would be the best colour for the office door. The interview was closed by the following important question and profound reply: "Councillor L. Walker asked Lord Kelvin how long he thought the extensions would take to complete them, that is, the extension now in progress? Lord Kelvin could not say, as much would depend on the builder, and otherwise, but he hoped they would be finished in good time for the winter requirements." It is a great pity that someone did not ask for Lord Kelvin's views as to the rate of propagation of gravitation; it would all have come into the day's work, and the ratepayers could hardly have objected.

The Technical Education Board of the London County Council has published the conditions under which it is prepared to grant aid to the carrying on of evening science classes. Careful thought and a considerable amount of experience of the virtues and vices of science classes is exhibited in the schedule. In one respect particularly the Board is to be commended, namely, in its decision to afford no assistance whatever to classes which are "farmed" by the teachers, or in which the system of payment by results is practised. This viciously inefficient system deserves to have the full weight of all constituted authority against it. In regard to the experimental sciences, the Board is no less careful that its aid shall flow into proper channels; for it stipulates that provision shall be made, "not only for the experimental illustration of the lectures or class teaching, but for experimental work by the students themselves," and that "every lecture must be followed by at least one hour's practical work on the same evening or some other evening in the same week."

Another important element of true instruction which it is sought by the Board to foster is the practice of setting "home work." This is stipulated in connection with the mathematical and geometrical subjects, and is a most satisfactory proviso. The mere attendance at lectures, necessary though it is for acquiring a head knowledge of these subjects, is of little or no use in imparting that facility and skill in the practice of them without which they are of no technical value. A number of small scholarships will be awarded by the Board some time next November. Not more than 100 of these will be awarded to boys, and not more than 100 to girls; and the value of the scholarship will include free education at such schools as the Board may approve, and a money payment of £8 during the first and £12 during the second year of tenure.

Some observations are made in *Industries and Iron* on the waste of work at those technical colleges in which students are put to original research by way of instruction; and some good suggestions are made as to researches which are well worth carrying out, but which engineers have no time to follow up at their works. One of the best and most simple of these suggestions is the following:—

The carrying capacity and resistances of hot wires for use as rheostats for large powers are also well worthy of investigation. If iron is used there is an uncertainty about the temperature coefficient, and the specific resistance, so that it is difficult to know beforehand what a given set of spirals will do. If a more expensive metal or alloy is used what is wanted

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is to get the largest surface with the least metal; that is to say, the wires should be as thin as is compatible with mechanical strength and durability. This is often overlooked, and resistances for large currents are made of large wire, whereas several small wires in parallel would be cheaper. The information wanted is the carrying capacity of spirals of different pitches and diameters, of wires of different gauges of copper, and various definite alloys. Another form of resistance is very convenient. It consists of strips of iron, lead, or other metal immersed in water. This form is cheap to make, and very convenient; but information is again required as to the carrying capacity of various wires under water. Here is some more work for technical colleges.

It is, however, easier to make the suggestion, than to induce ambitious students to relinquish "the measurement of simple resistances by the five-split dynamometer method; the critical state of hypothetical dynamos run at half-speed with double load." We shall be very glad to receive from our readers any notes about the carrying capacities of spirals of different pitches and diameters, and of strips of metal in water, and would collect and reduce their observations to some general rules for the construction of such resistances. It would always be open to the college experimenters to show that owing to suppressing the variation of g with the latitude, or some such error, everybody else's results were wrong.

We publish this week two articles which we flatter ourselves are of a peculiarly seasonable character, relating as they do to lightning. The notes sent us by Mr. Doran serve mainly to show once more what lightning can do when put to it, but since it is only from the laborious collection and collocation of accurate data of this kind that the next advance towards a satisfactory theory of lightning and lightning protection can be looked for, the account in question may perhaps be of some use to our future generaliser. In the experiments of M. Massin we have an attempt, not indeed to secure a unit lightning flash, but to secure a unit lightning guard in the shape of a certain plate protector; the behaviour of other types being expressed in terms of the air-gap that it is necessary to give the standard protector in order to secure a balance in the Wheatstone Bridge arrangement adopted. In addition to reproducing the average practical conditions as near as may be without the dangerous collaboration of a good thunderstorm, M. Massin's method of testing the relative effectiveness of plate, comb, and mica-sheet protectors seems likely to lead to sound conclusions as to their relative effectiveness. M. Massin certainly condemns the mica protector, but as he apparently used a solid sheet of talc instead of the perforated sheet adopted in the British Post Office pattern, his condemnation does not necessarily mean that either his experimental methods lead to erroneous conclusions or that the Post Office pattern is all wrong.

We hear that a unit of earthquake has been decided upon and adopted in a Paper recently read before the Royal Society, so that the magnitude of a seismic convulsion can now be scientifically expressed to any number of decimal places. To be quite scientific, however, the C.G.S. system should be used, and the earthquake should be expressed in terms of length, mass, and time and all the suppressed dimensions. Omitting these latter, the C.G.S. unit of earthquake might be defined as that amount of quake which, acting on a gramme mass of the earth's crust with a frequency of one harmonic vibration per second, would cause it to heave up and down with an amplitude which would increase at the rate of one centimetre per second. Then the unit should have a name—that of some famous defunct seismographer would probably be the most serviceable; and there should be a huge "practical" unit, and a microscopic "absolute" unit connected together by 10 to no end of powers. But perhaps the unit selected is not "scientific"—only convenient.

The Compagnie Edison.—This concern is stated to be contemplating adopting Brown apparatus in its future undertakings.

Free Technical Education.—A gratuitous course of lectures in electricity has been inaugurated at the Maison des Ouvriers, in Brussels, under the direction of M. Buse, jun.

The International Electrical Congress.—It is stated that the Congress Committee on Invitations has issued nearly 950 individual invitations. It is expected that the attendance will amount to not less than 500.

Chicago Exhibition.—Information has been received that the judges have at last got to work. Amongst the British judges, we note the names of Profs. Ayrton and Forbes (Electricity), Prof. W. Cawthorne Unwin (Machinery), and Prof. Silvanus Thompson (Instruments of Precision: Liberal Arts).

The City and South London Railway.—The passengers on the down line of the City and South London Electric Railway were inconvenienced on Tuesday evening last by the bursting of the hydraulic main at the Oval Station. Before the supply could be turned off the water had partially flooded the line, and it was with great difficulty that the trains could proceed.

Fire Prevention and Extinction.—A gold medal of the value of 1,000 lire is offered by the Royal Academy of Science of the Institute of Bologna to the author of the best memoir describing a new and efficacious system, or a new apparatus, for preventing or extinguishing fires. The memoir may be written in Italian, Latin, or French, and must be sent in before May 7, 1894.

Underground Telephone Wires.—In reply to a question in the House of Commons last week, the Postmaster-General stated that the powers to place telephone wires or tubes underground either in London or other towns were regulated by statute, and were in all cases subject to the consent of the Local Authorities, with an appeal in certain cases to a police or stipendiary magistrate or county court judge, and a further appeal to the Railway Commissioners.

Earthing Alarum.—The *Electrical World* describes a novel form of fault detector, consisting of a modified form of electric bell. The device is intended for use with storage batteries. When a fault puts the line to earth for more than a prearranged time—which can be varied from one to 20 seconds—the bell rings. While the bell is ringing its resistance and back electromotive force are such that the leakage current is cut down to a very low figure.

Photographing Flying Bullets.—E. and L. Mach, who have done a considerable amount of work in connection with the photography of flying bullets, air jets, and sound waves, recently communicated the results gleaned from a series of about 1,500 negatives to the Vienna Academy. Sharp images of Mannlicher rifle bullets were obtained of 3·5cm. diameter. The experimenters closed the spark circuit mechanically by means of the sound wave produced by the bullet itself.

Coventry.—At the quarterly meeting of the Town Council on Tuesday last the report of the Electric Light Committee recommending that the Corporation undertake the supply of electrical energy under the Provisional Order, that the high-pressure, alternating-transformer system be adopted for private lighting, and that street lighting be not at present undertaken, that a site be purchased in Sandy-lane, and that a consulting engineer be employed to advise the Committee upon the selected specifications and estimates was adopted.

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Lord Kelvin.—The August number of the *Review of Reviews* contains for its usual character sketch an article on Lord Kelvin from the pen of Mr. J. Munro. A very interesting *résumé* of the salient points in the life of Lord Kelvin, whom the writer styles the Napoleon of Natural Philosophy, and of his principal conquests in the domain of science, is to be found in this article, which electricians will no doubt find to be instructive and pleasant reading. The article is accompanied by several portraits of Lord Kelvin, and views of his residence and of Glasgow University.

The Kashmir Telegraph Line.—Good progress, says the *Indian Engineer*, continues to be made in laying the new permanent telegraph line between Srinagar and Gilgit, and the work will be completed by the end of September. It is intended to maintain two posts of observation between the Passes during the winter months, so that breaks due to the snow or avalanches may be rapidly repaired. As these posts will be completely cut off from the outside world for many months, they will be fully provisioned, and parties of picked men only will be stationed at them.

Naval Electric Signal Lamp.—Advantage has been taken of the naval manœuvres, says the *Army and Navy Gazette*, to compare a new electric masthead flashing lamp, submitted by Sir Wm. Armstrong and Co., with the service pattern lamp. In the former the light is enclosed by a number of shutters, which are caused to open or shut, in the latter the operator switches on and off the lamp. On board the "Royal Sovereign" one lamp was placed at the foremast head, and the other kind at the main, and signals made with them. The Fleet were unanimously in favour of the shutter lamp, on account of its sharpness and clear definition of the long and short flashes.

Wild Horses and Electric Eels.—It seems that Humboldt, like the too credulous Herodotus, must have been "taken in by a native" when he heard and put on record the story about the capture of electric eels in South America by driving wild horses into the pools where these seats of electromotive force are to be found. It appears that a writer in the *Spectator* who has travelled on the llanos of Caracas — where Humboldt heard the story—has been making inquiries himself, and has failed to find any confirmation of this method of capture; but that, on the contrary, these *trembladores*—as the eels are called—are caught in the most prosaic manner by means of nets and a lineman's india-rubber gloves.

The Cushman Dynamo.—One of the most novel features in this dynamo, which has recently been put on the market by the Granite State Electrical Company, Concord (N.H.), is the manner in which a well-balanced field is obtained at the polar surfaces. The field-magnets are of the well-known horseshoe vertical pattern; but instead of being bedded directly on to the frame they are supported on two short electromagnets, which are wound similarly to a double magnet dynamo. The carcase is, in fact, a double magnet in which one magnet—the upper one—is much longer and has more windings than the other. By this means heating at the bearings and other defects arising from want of magnetic balance are avoided.

The Gas Light and Coke Company.—The *Gas World* calls upon Mr. Preece and "other enthusiastic electricians" to witness its joy over the fact that, making allowance for all changes in price, the Gas Light and Coke Company's rental "in the very headquarters of electric lighting"—the West End—has gone up some 10 per cent. in three years. But, wherefore call on the electricians? The fact of there being such a headquarter of electric lighting only proves that gas has not got things all its own way; and the fact that the gas industry has improved 10 per cent. only means that more gas stoves and gas engines are in use. We are not surprised at the increase in the gas consumption; we are very glad of it; we expect to see another 10 per cent. in the next three years.

Trolley Boats.—A party of capitalists, says *Electricity* of Chicago, said to have some connection with the Santa Fé Railroad system, has been visiting the Grand Canyon of the Colorado River for the purpose of investigating the feasibility of laying an electric cable 500 miles in length along the river with which to drive small boats up through the Black Canyon and other scenic points, where the cliffs, over a mile in height, overhang the stream. Power is to be generated by water-wheels driven by the current of the river itself, or, wherever feasible, the water will be diverted into canals. A copper wire cable will be suspended over the centre of the river, which is, for the most part, about 300ft. in width, and electric power will be conveyed to small steamers as in the case of electric railways.

Worcester—At a meeting of the Town Council on Tuesday last the Mayor proposed the adoption of the recommendation of the Watch Committee to adhere to the original proposal to construct a generating station at Powick, on the banks of the Teme, for electric lighting purposes, and that the tender of Mr. Thomas Rowbotham, of Coventry-road, Birmingham, to construct the station at a cost of £14,797, be accepted. The City Chamberlain proposed an amendment to the effect that the Committee proceed to construct a generating station in Worcester at a cost not exceeding £20,000. On being put, 10 voted for the amendment and 22 against it. The original motion was then put and carried. Mr. W. H. Preece was appointed consulting engineer, and Mr. Leonard Wigan was appointed clerk of the works.

Measurement of the Resistance of the Human Body.—While engaged on some measurements on the electrical resistance of the human body M. Mergier was led to the construction of a simple instrument on the Evershed ohmmeter principle capable of making such a measurement with accuracy. The instrument consists of two coils of insulated wire, fixed with their planes at right angles to each other, and placed within the field of a strong horse-shoe magnet. These two coils are connected in series with the resistances to be compared, and to the terminals of a battery. Under these circumstances, the position of equilibrium of the coils depends only on the ratio of the resistances of the two branches (coil and added resistance), and is independent of the value of the electromotive force of the battery.

Telephone Subscribers' Agitation at Rotherham.—A meeting of the Rotherham subscribers to the service of the National Telephone Company was held last week. The Company, it seems, has given notice to increase the rental from £5 to £8 per annum. After discussion, the meeting expressed itself in favour of the present rate, or the alternative course of dispensing with the service. A very general feeling was manifested in the direction of an improvement of the service, and complaints were made of want of attention at "The Central," and of difficulty in telephoning with Sheffield and outside districts. It was decided to communicate the views of the meeting to the Manager. It was announced that there were 126 subscribers in Rotherham, and that more than one-third of this number had given their opinion on the proposed charges.

A Municipal Tax on Electricity.—A very curious question, says *La Lumière Electrique*, has recently been disposed of by the civil tribunal at Vigan. This town had rented out its municipal taxes to a M. Carrière, and among the dutiable articles over which this gentlemen thus acquired control were petroleum and candles. In course of time the municipal authorities gave their sanction to an electric lighting scheme, and permitted the new mode of illumination to go untaxed. The result was a certain falling off in M. Carrière's revenue, owing to the lessened consumption of candles and oil. M. Carrière naturally made complaint to the civil authorities, who accorded him damages to the amount of 400fr., and decided to hold the electric light company responsible to the municipality in respect of any further injury to the taxation.

Bradford.—At the meeting of the Town Council on Tuesday last, Alderman F. Priestman (Chairman of the Gas and Electricity Committee), in moving the adoption of the minutes of that committee, gave his half-yearly statement. In the electric lighting department he said that the sales up to the end of June 30, 1893, were £4,210, against £3,126, and the gross profit for the half-year was £2,293, against £1,673, whilst the net profit was £625. 16s., against £387. 7s. for the corresponding period. The total expenditure on the electricity works was £62,109, and there was a profit balance on the whole of the working of £915. 12s. 6d. He also included in his motion a

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recommendation that the necessary work required in connection with the application of the "three-wire" system, at an estimated cost of £2,020, be proceeded with; and that the Council accept the tender of Messrs. Siemens for the supplying and fixing of two engines, with dynamos, and two switchboards, for the sum of £3,025. The motion was carried unanimously. It was also agreed to pay the Westinghouse Company £2. 10s. per annum per ton of copper actually laid down for the use of the Hopkinson three-wire patent.

Electrical Resistance of Thin Liquid Films.—In a Paper recently read before the Royal Society by Profs. Reinold and Rucker, "On the Thickness and Electrical Resistance of Thin Liquid Films," the authors have shown that a discrepancy arises between the results when the thickness of a film is measured optically and when it is measured electrically on the assumption of a constant specific resistance. The discrepancy is such as to indicate that, in general, the specific resistance of the film falls as the thickness is reduced. The Paper concludes with a discussion as to the cause of the increase of electrical conductivity of thin films. The authors point out that it may be attributed either to a modification of the chemical constitution of the film, brought about by its tenuity, or to the formation of a pellicle on the surface. They prove that the experimental results cannot be explained by the formation of the pellicle only, but that they are consistent either with the former or with a combination of both causes. To discriminate between them it will be necessary to carry out observations in gases other than air, and an apparatus specially designed for this purpose is being constructed.

Damage by Lightning.—The following list is interesting, as showing some of the damage by the thunderstorms of Thursday last week:—

Helensburgh	Farmhouse struck; telephones damaged.
Devizes	Belfry demolished.
Lynn	Oat stack fired and destroyed.
Heywood	Mill damaged.
Bakewell	Farmhouse struck.
Melton Mowbray	Horses injured.
Shillingford	Nine beasts killed.
Belfast	Mill fired.
Near Omagh	Belfry destroyed.
Banagher	Church struck; cattle killed.
Near March	Horse and man killed.
Ballymarlow	Flax mill burnt.
Boston	Stack of wheat fired.
Dunmow	Farm struck.
Folkestone	Two houses struck.
Ashby-de-la-Zouch	Cattle killed.
Great Coggeshall	Church tower destroyed.
Sheffield	Chapel struck.
Alderton	Woman killed.
West Mersea	Chimney struck.
Holyhead	Man killed.

In Paris a house was fired. Within a hundred yards of this a woman who happened to be passing along the street with a baby in her arms was killed, together with the infant. A similar occurrence took place at Cappelle, where a woman who was leading a child was killed, the child being rendered unconscious. At Doudlens two men were killed.

The Mende Central Station.—The Mende central station, which was started in 1888 was, says *L'Industrie Electrique*, laid down as a steam-power station, the plant comprising two high-speed engines of 120 H.P. each coupled direct to 75 kilowatt dynamos. As, however, the maximum output never rose above 45 kilowatts financial considerations rendered a reorganisation of the station necessary, and a waterfall being available about two miles outside the town it was decided to make use of it, but as it gave only 35 H.P. in summer storage batteries were necessary, and to keep the number of these down as much as possible the following intricate device was resorted to. The shunt-wound 800-volt generator at the fall supplies current to a 600-volt motor, driving a 105-volt 250-ampere dynamo feeding the lamp circuit. In parallel with the lamps is a series-wound motor coupled to a small dynamo. The field of this dynamo is double-wound, one set of coils forming part of the motor circuit, the other being taken off the omnibus bars. During the hours of light load this auxiliary machine gives 200 amperes, and adding 30 volts to the 105 volts on the lamp-circuit charges the accumulators. As lamps are switched on the current in the motor circuit winding diminishes, reducing the electromotive force of the auxiliary machine to 5 or 10 volts; the poles are then reversed and these 5 or 10 volts are added to the battery which then discharges through the lamps. As a 60 H.P. steam-engine is kept as a stand-by it is somewhat difficult to realise the value of a waterfall entailing so much complication.

The Absorption of Light by Platinum.—Dr. G. B. Rizzo has constructed an ingenious piece of apparatus, recently shown at the Accademia delle Scienze di Torino, for obtaining thin films of platinum on glass by electric volatilisation. The difficulty hitherto experienced in the investigation of the change of transparency of thin metallic films with the temperature has been to keep the films from oxidising. Dr. Rizzo's apparatus consists of two glass cylinders joined by a thin tube soldered in a T-joint to another leading to an air-pump and a reservoir of nitrogen. Both the cylinders contain platinum electrodes, one of which is sheathed in glass along half its length. By repeated filling, the composite tube is made to contain a rarefied atmosphere of nitrogen. On connecting the glass-sheathed electrode to the negative pole of an induction coil, worked by six Bunsens, and making circuit, the unprotected half of the electrode is rapidly volatilised and deposited in a thin even film on the walls of the cylinder. Nitrogen is then allowed to enter up to atmospheric pressure, and the cylinder containing the film is melted off. The electrode is bent out of the way by softening the junction of its glass sheath, and the cylinder is mounted in a small furnace heated by a spiral tube of gas jets and provided with windows. To determine the transparency at various temperatures, light is sent through the walls of the cylinder near the edge of the film, and the intensities of the various wave-lengths transmitted outside and inside the edge of the film are measured by the spectro-photometer. Dr. Rizzo found that the transparency of platinum increased with the temperature, especially in the more refrangible region. According to the electromagnetic theory of light, both the resistance and the transparency of a conductor should increase, and the resistance and transparency of a dielectric should diminish with a rise of temperature. As far as these experiments go, therefore, their results are in perfect agreement with this theory.

Electrical Markets in Spain.—English electrical firms, writes a correspondent, ought to begin to think of the Spanish markets. It does not by any means do honour to the proverbial British enterprise to see how such an important and accessible field is being left almost entirely in the hands of German and French firms. Very little seems to be done to bring before the notice of the Spanish public what we can do. The numerous Spanish technical publications are crammed with advertisements of foreign firms, but the names of British houses are conspicuous by their absence, the only one which seemed to show some interest in this respect having now disappeared from the Spanish arena on account of financial difficulties at home. I have seen an illustrated catalogue published in Barcelona. It contains cuts of several dynamos of the Brush type, and other appliances of English make, and, although the descriptions are given in rather bad Spanish, the get-up is very practical, having a decided advantage over most trade catalogues issued in England, *i.e.*, the quotations are given in Spanish money, and the measurements according to the metric system. Unfortunately, the most important English concern in Spain, the Electricity Supply Company for Spain, is hardly yet a success, for the balance-sheet, which was not published in the *Gaceta* until May 19th last, dated the 14th of the same month, showed a deficit, referring to which the *Revista Minera*, of Madrid, says: "In our opinion, to lose this money is far more clever than gaining it, considering the great demand the electric light has always met with here, and the relatively small competition the Company has had to face." A good opportunity for English engineers and manufacturers to study the Spanish markets and vindicate their prestige will be the forthcoming International Exhibition at Madrid, which is to be held at the Palace of Arts and Manufactures from May 1 to October 31, 1894. The exhibits are to be distributed in fourteen groups, one of them being "Electricity."

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THE SMYTHE-PAYNE SYSTEM OF FIREPROOF WIRING.

The premises of Messrs. J. and B. Stevenson's restaurants, and other business houses in the City, have recently been wired for the electric light on a fireproof system invented and carried out by Messrs. Smythe and Payne.

The essential features in this system, which we described at its first inception, consist in the use of bare copper conductors, and of insulating and protecting materials, which are incombustible nnd imperishable under ordinary conditions. These features are arrived at in a great variety of ways, which, though the general character of them all is the same, are severally suited to different classes of work. Thus, for some purposes a pair of concentric tubes, composed of rolled copper, separated by porcelain rings placed at frequent intervals, and protected by being placed inside an iron, brass

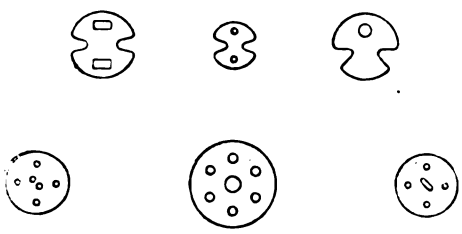

Fig. 1.—Smythe and Payne System of Wiring. Porcelain Separators.

or other metal tube, is used. On other occasions the conductors are composed of bare wires or thin strips of tinned copper, which are threaded through porcelain insulating separators of various shapes, some of which are shown in Fig. 1, the whole being drawn through either rigid or flexible metal tubing, to serve as a mechanical and water-proof protection, according to requirements.

The details of the system appear to have been very completely worked out; for suitable forms of switches, fuses, lamp attachments, &c., have been designed for use with the tubular wiring; and the difficulties met with in going round bends and making curves in the wiring have been boldly attacked. One method of wiring at a bend, which is used in the premises we have named, is illustrated in Fig. 2. Here there are three bare copper wires, which on each of the straight lengths that meet at the bend are carried in metal tubes, and separated by porcelain insulators. These insulators are of a circular or disc-

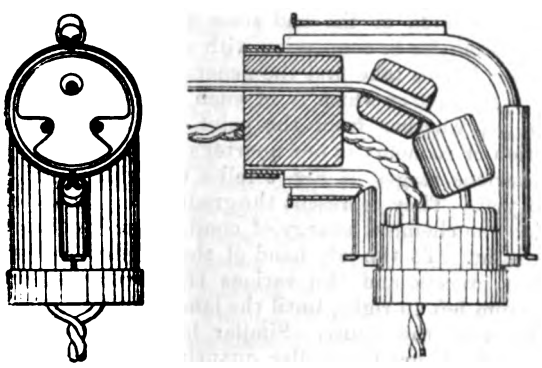

Fig. 2.—Smythe and Payne System of Wiring. A Bend.

shaped form, with two deep indentations for carrying two of the wires, and with an eccentric hole, through which the other wire is passed. Between the porcelain insulators the two wires, which are laid in the indentations, are twisted together into one conductor, whereby the insulators are prevented from movement along the wire. The bend in the outer tube consists of two bent semi-cylinders, the edges of which are flanged. These are stamped in sheet brass, and are placed with their flanges abutting so as to form a tube round the conductors. The ends of this brass tube lap over the ends of the straight lengths of metal tubing and are clamped to them by means of a couple of rings. The flanges are secured by means of a channel key which is slid over them; and all the seams are made secure and watertight with solder. Contact between the bare wire and the metal tube is prevented, at the bend, by means of a couple of porcelain rings, which are threaded on to the wire as shown in the illustration.

Another mode of making a bend in the wiring is shown in Fig. 3. In this the two outer pipes which are coupled together are effectively insulated from one another, so that a contact between a conductor and any section of pipe cannot establish an earth through the whole system of pipes. The coupler consists of two porcelain angle-pieces, provided with

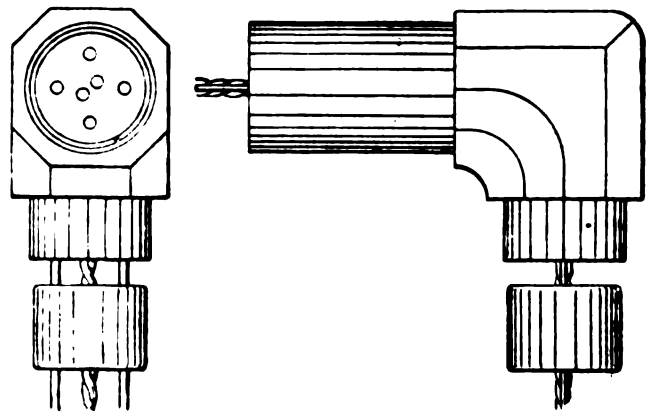

Fig. 3.—Smythe and Payne System of Wiring. A Bend.

circular plugs, which can be fitted into the two tubes. At the surface of contact between these angle-pieces, which is indicated by the curved line in Fig. 3, there are a number of grooves or channels which form separate conduits for the isolated bare wires and effectively insulate them. It will be noticed that in

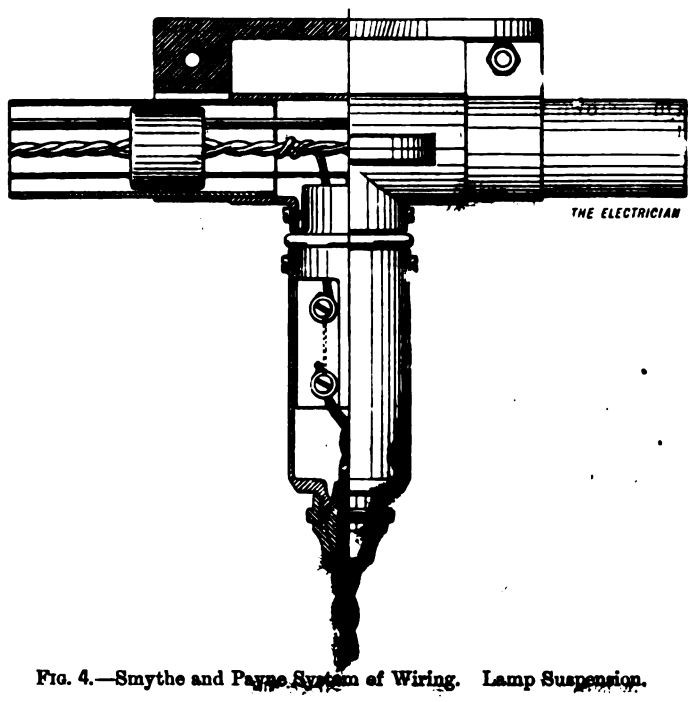

Fig. 4.—Smythe and Payne System of Wiring. Lamp Suspension.

the illustration there are holes in the circular separator for six wires, namely, for two near the centre, which would be twisted together, similarly to those in Fig. 2, and for four others which would be isolated from one another and drawn straight through the system of tubing. The advantages claimed for this practice are that it very much reduces the number of joints, as it enables a wire to be drawn through from the switchboard to the lamp in one uncut length.

One of the methods by which a lamp is suspended from a line of wiring is illustrated in Fig. 4. Wires for several lamps are passing through the length of horizontal tubing which, at this place, is supported from the ceiling by means of a light

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cast-iron hanger. A T joint is made by flanging the fuse-box on to the lower part of the tube, and from the porcelain fuse-holder, which is contained in the lower part of the T, and which is protected by an ornamental brass casing, the covered flexible wires are dropped down to the lamp. One of the isolated wires is bent down to the positive fuse, and the central twisted return wire is connected to the negative fuse by a readily-jointed short length of bare wire. The negative fuse is shown by a dotted line, and the positive fuse is symmetrical with it on the other half of the porcelain holder.

It has been possible to give in this short article a description of only the main features of this mode of wiring, which has been most thoroughly worked out. The system has been subjected to a trial of several years' work in the lighting of many buildings, and has been found to fulfil the requirements of an effective mode of wiring. As was remarked in our former notice of this system, it is particularly well adapted for banks, offices, shops, churches, and other public buildings where the outer tubes can be boldly run without need for concealment. We understand that as it is merely fixed to woodwork by screws, the wiring and its cover remain a "tenants' fixture." In one or two cases closely spaced insulators have been drawn into compo tubing. This suggests a very convenient form of conductor for ordinary house-wiring, and we are informed that for the larger sizes, taking ten amperes or so, such a cable with one or more pairs of wires can be supplied at the price of first-rate rubber insulated cable and casing. The insulators would, of course, have to be set close to allow an easy bend to be made at any point.

CURIOUS EFFECT OF LIGHTNING NEAR QUEENSTOWN.

We have received from Mr. C. G. Doran, of Queenstown, some interesting particulars of the effects of a thunderstorm which passed over that town on June 19th last. The storm approached Queenstown from a south-easterly direction, and seems to have been of a singularly destructive and deadly nature; for several

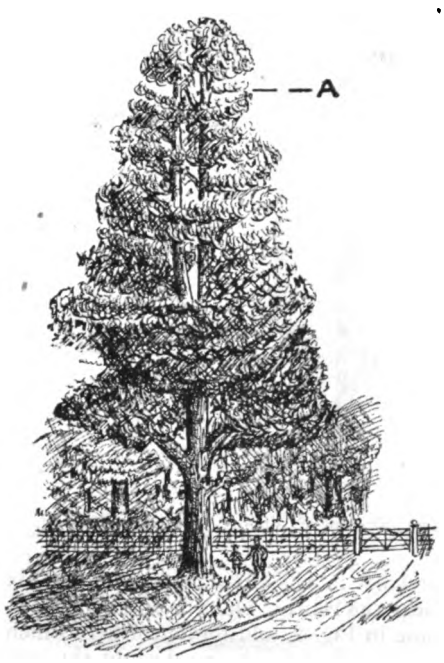

Fig. 1.

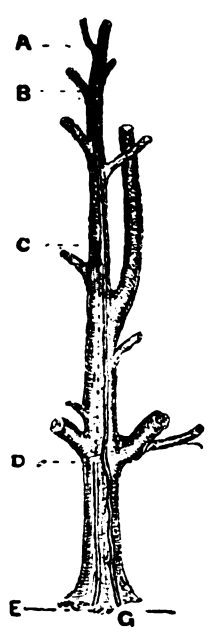

Fig. 2.

deaths resulted from the lightning. When immediately over the island of Fota, a beautifully wooded island in Cork Harbour, on which is situated the residence of Mr. Smith-Barry, M.P., a vivid flash struck the top of a lofty elm, which stood somewhat apart from the plantation of other trees, and about 9ft. from an iron fence which surrounded the thicket in which these trees grew. Fig. 1 shows the tree when viewed from the N.N.E. It will be noticed that towards the middle of its height the trunk divides into two stout limbs, which are but slightly separated and run parallel to one another to the top. The estimated height of the tree is 60ft., and its girth at a point 2ft. above the ground is about 8ft. The lightning flash struck the northern limb at the point indicated by the letter A, which is nearly 50ft. from the ground and several feet below the top of the tree. The branches and foliage above this point do not appear to have been affected in any way by the lightning. Passing downwards, the discharge grooved out a narrow channel in the bark and outer timber, till it reached the point B, in Fig. 2, when it suddenly shifted round the trunk to a point S by W; it then followed the tracks indicated by the letters, C, D, E, and G, to the ground. In Fig. 2, the foliage is omitted in order to show the trunk more clearly, and it may be well to remark that the diagram is not intended to convey that Fig. 1 became reduced to Fig. 2 by the lightning. At the point C, which is about 25ft. from the ground, the discharge seems to have divided, a portion taking the course to G and another portion travelling beneath the surface, through the wood tissue till it reached D, where it again appeared on the surface and chiselled out a downward course to E. Wherever the discharge travelled over the surface of the timber it seems to have slotted a clean channel in the bark of uniform width and thickness, and to have splintered out the underlying wood tissue over an equal width. We have received samples of the bark and wood, and it appears that the width of the strip of the former material which was peeled off along the groove, A to G, was uniformly an inch and a-half. The second groove, D to E, was, however, only an inch wide by about an inch deep, *i.e.*, the depth of the bark alone. The groove in the wood, wherever it occurred, was uniformly an inch and a-half wide by a quarter of an inch deep. The portion of the discharge which took the course C, E, passed to earth along one of the roots of the tree, which it violently disturbed. The other portion disappeared at G without doing any further apparent damage.

POSSIBLE AND IMPOSSIBLE ECONOMIES IN THE UTILISATION OF ENERGY.*

BY PROF. ALEX. B. W. KENNEDY.

(*Concluded from page 393.*)

I have reserved to the end some discussion of possibilities and impossibilities in connection with some complete industrial processes. Let us take first the generation and distribution of electricity, a matter which is of such keen interest now to so many of us, whether from the point of view of economy in production or economy in our quarter's bills!

The various stages of Fig. 9 tell a tale which, perhaps may interest you. They represent the gradual degenerative process by which the chemical energy of combustion is converted into electric light. To the left hand of the diagram is represented the boiler process, and the various transformations are represented from left to right, until the lamps are arrived at on the right hand of the figure. Similar letters are used in each section of the figure for similar quantities of energy. In each section the losses of the section before are written off, and the heat actually carried forward is called 100 per cent. K represents the losses in the boiler, which is assumed to have an efficiency of 80 per cent. H represents waste mainly due to condensation in steam pipes, and also to the driving of pumps, and other such losses inevitable in a central station. The third section represents the whole heat which has been received by that portion of the steam which actually found its way to the main engines, and of this, G is the part unavoidably lost from thermo-dynamic limitations (*see* Fig. 4). In Section IV. the heat actually received by the engine is called 100 per cent. Of this, the area F is wasted, and the remainder turned into work. Section V. shows the whole heat turned into work by

* Lecture given at the Royal Institution, April 21, 1893.

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the engine as 100 per cent., of which the area E represents the energy necessary to drive the engine itself, which, therefore, never reaches the dynamo. In Section VI. the energy received by the dynamo is taken as 100 per cent., and the area D represents the dynamo losses, which are wonderfully small. The energy—now in the form of electrical energy—which leaves the terminals of the dynamo, is represented by 100 per cent. in Section VII. Of this, a certain proportion, sometimes small sometimes large, but here represented by C, is expended in mains, transformers, or batteries, and never reaches the lamps. Finally, at the right-hand side of the figure we get the energy received by the lamps as 100 per cent., out of which only this small, almost insignificant, quantity A is turned into light, the huge remainder B being once more converted into heat. If the side of the area A in Fig. 1 be looked at, it will be seen what an insignificant quantity of the whole heat of combustion it actually and finally turns it into its intended purpose. The result savours a little of the ludicrous. Let us go back and review its possibilities. The losses K, I need not deal further with. H represents losses, about which we engineers feel very sore, and which sometimes try our temper and our patience greatly. It is so annoying to have a kind of additional gratuitously-superfluous loss—not dealt with in text books, not recognised as having any kind of respectable existence—thrust in upon us. The temptation to muddle it up with K or G is very great; but if it is really to be got rid of, or even greatly

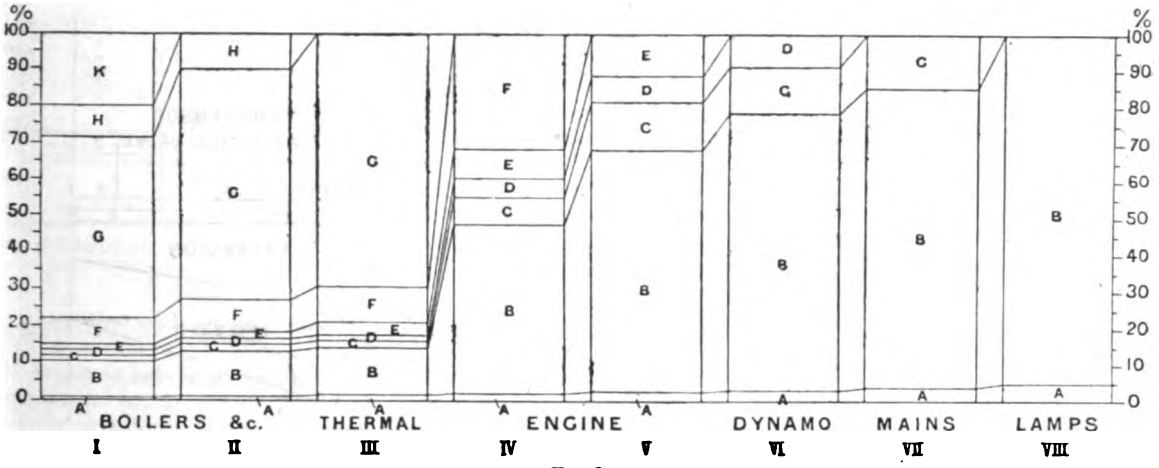

FIG. 9.

reduced, it must be faced. I will not, however, trouble you about this; it is a difficulty in domestic politics, and should, perhaps, not be brought into publicity. To quote one of Mr. W. M. Conway's remarks in an entirely different direction, "It would be a breach of confidence to let the ordinary reader into the secrets of these things."

G and F I have already dealt with in connection with Figs. 4 and 5. E and D do not look very promising as fields for radical improvement. There are few things I think more creditable to modern engineers than the smallest of the losses represented by D. Only about 60 years ago Faraday made his copper disc machine, which, I believe, is still in this building. It is hardly 25 years since dynamos, as we now understand the word, were invented. Even 12 or 15 years ago the description of a dynamo as a combination of brown paper and copper wire stuck together with shellac and dotted over with mica was not without some sort of foundation in fact. But now, thanks to the combined scientific knowledge and mechanical skill of the engineers who have taken this matter up, some of the foremost of whom I have now the pleasure of seeing in this room, the dynamo is not only excellent in its mechanical design, but so high in its efficiency that it can, and does, give out as electrical work something like 92 per cent. of the mechanical energy which it receives from the steam engine. Of the remaining 8 per cent. about a quarter is taken up in supplying the magnetising energy, and I daresay the dynamo makers would tell us that they would make the remainder almost disappear if they could only get people who would pay a high enough price for the machines.

I do not think that the distribution losses C are likely to be reduced to any very sensational extent below the figure at which I have put them. We frequently hear of their almost negligible magnitude, but whenever they get really measured, the sum of a number of things which separately are supposed to be so minute appears to be anything but negligible. No doubt the 15 per cent. loss will be gradually driven back to 10 per cent.; but it will be hard work, and will come about only by degrees and by care and pains in detail, not by any new system of distribution or by any striking invention.

But truly in our last stage we have got one in which improvement is needed and in which we all hope that enormous improvement is possible. Moreover, here I can no longer adopt the Philistine attitude, which I fear I have had to take up so much, and say that improvement is a matter of detail and of common sense only. On the contrary, here is a case where we know beforehand that we may any day be surprised by a discovery, on the part of one of the many men who are devoting time and thought to the matter, which may even enable us to multiply manifold the amount of light which we can obtain from a given quantity of energy. At present to obtain light, I speak of glow lamps only, we have to pass a current through a carbon filament in such a fashion as to make it white hot, and it is only because it is white hot—*i.e.*, because we expend energy in heating it up—that it gives light. Of the whole electrical energy received by each of the lamps in this room, probably 95 per cent. is expended in heat and only 5 per cent. in the actual light rays, as is indicated in my diagram by B and A respectively.

To obtain light without heat, or with a minimum of heat, that is the point. Much as I should like to tell you from what direction the improvement must come, I fear I cannot. Mr. Tesla gave a certain lecture here which many of you may remember; you will certainly do so if you heard it. Our friends in the newspapers told us next day, possibly misled by some pardonably incautious enthusiasm on the part of the lecturer, that at last the hour had come, electric light was to roam the universe at large, and you had only to put a tin plate on the ceiling and hold a lamp in your hand for the whole room to be lit up! No more quarterly bills at 8d. per unit, or even 6d., no wiring of houses—universal brotherhood and current for nothing. Perhaps the papers would not have been so sanguine if they had known, what I believe was the fact, that the gas engine which lights this whole building easily was hard put to to supply energy for Tesla's experiments, and you will remember that the most striking and beautiful of them hardly did more than make the lecturer visible. It would be sanguine to hope that the light of the future will be economically worked out on those lines.

It is often suggested that we should go to the glow-worm and study that little animal. Any of you who have tried will no doubt remember what a very disappointing little animal he is. His light is so clear from a few yards off that you think

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he must be really bright, but when you examine him from the point of view of looking for *light* you find there is a terribly small amount to look for, a candle would be a conflagration in comparison. It is possible that the glow-worm line—if we only knew exactly what the line was—is the one to be pursued, but it also looks unpromising at the outset. But no doubt the man who works out the problem successfully will be of sterner stuff and more sanguine temperament than to criticise destructively at the outset. People who criticise never make inventors.

Fig. 10 represents, in a condensed form, the losses which occur in the transmission of power on an electric railway or tramway. Here, I have not gone back to the boiler, but have taken the work done by the main engine as 100 per cent., so that Fig. 10 really corresponds to Sec. V. of Fig. 9.

Fig. 11 is drawn in the same way, and represents the result of some experiments which I made in the year 1889 in Paris, in connection with Popps's system of compressed-air distribution. Time fails me to discuss these diagrams in any detail; I merely put them before you as possibly of interest.

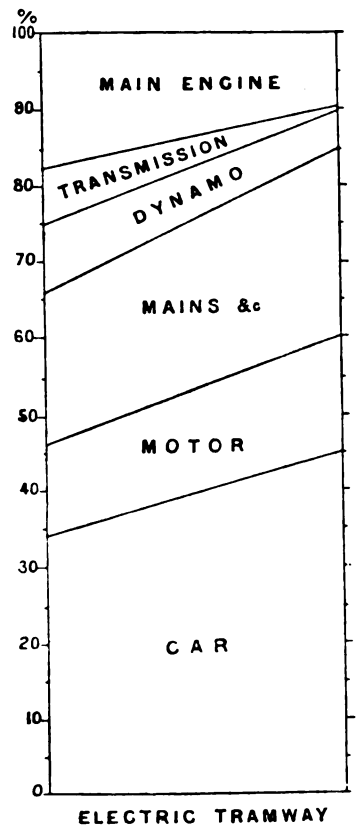

Fig. 10

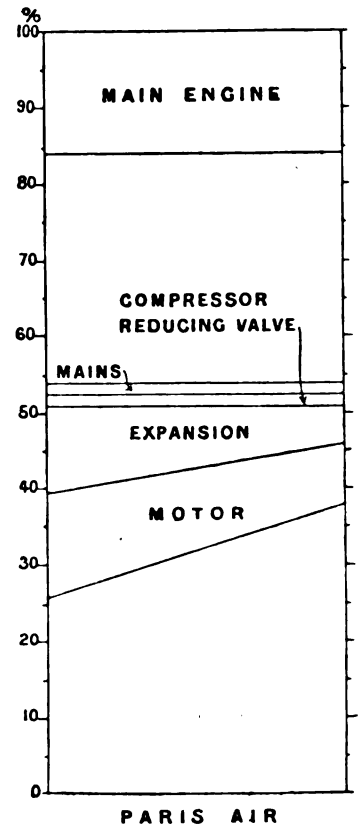

Fig. 11.

I am sorry, so close to the end of my lecture, to have to spring a new idea altogether upon you; but it is a matter which has so close a relation to my subject, and one which is so much overlooked, that I must not leave it out. I have given you certain ratios, certain efficiencies, which can be, have been, and are constantly being reached in the carrying out of physical processes on a large scale. But in estimating and comparing the economy possible in different cases, we must be careful that the conditions are similar. Thus in a boiler test an efficiency of 75 per cent., or even 80 per cent., can be obtained with care. But this supposes the boiler to be steadily and continuously worked. In point of fact, except on board ship, and in a few cases on land, our working conditions are widely different. In an electric light station, for instance, one boiler may be required all the 24 hours, one more for 20 hours, one more for 16, and two more for 8 hours. It is clear that for all of them except one these are long hours when they are doing nothing, but during which, nevertheless, they are burning some coal, if only a little. I find that with very great care the loss due to this cause can be brought down to from 8 to 10 per cent. I have often heard it estimated at double this figure. It is quite possible that one may find some way presently of reducing this loss still further, but at present even in the best practice it makes the average results of continuous work to fall woefully short of the results of tests even of considerable duration.

With engines and dynamos, but particularly the former, we get another set of conditions which tend to reduce the average economy below that due to experiment. The wasted work shown in Fig. 9, Section V, and marked E, is not proportional to the full power, but is practically constant at all powers. Hence at half power, instead of 12 per cent., we waste 24 per cent., at one-third power 36 per cent., and so on. It is easy to say that engines should always be worked at full power, but as the power required is very frequently quite beyond the control of the engineer it happens that the average load in almost all cases, except that of marine or pumping engines, is much less than the full load, hence a corresponding reduction of actual efficiency. As in the case of the boilers, the possibilities here are only of improvement by skilful design and management. They are none the less to be looked for and to be constantly kept in mind. Much more can be done by most of us by economy in this direction than is to be hoped for by any radical improvement in maximum possible efficiency. The work of the executive engineer is to take the *maximum possible* as he finds it, and devote all his energies to bringing the *actual average* as near that *maximum* possible as he can. These problems may be summed up as those affected by what Mr. Crompton has most happily called *load factor*.

There is yet another direction in which possible economy is to be looked for, a very fascinating one, and by no means an unpromising one. Look for a moment again at Fig. 9. Except only the process at the lamp itself, all the transformations have fair economy, so good that one sees at once that no radical defect exists in them. But cannot some of these be done away with altogether? It is the number of them that tell, and bring down the final result. Even half-a-dozen transformations of 90 per cent. efficiency each bring us down to about 50 per cent., or cannot we substitute for III. in Fig. 9, some more effectual process?

If an ordinary gas engine be substituted for a steam engine we cut out the question of boiler efficiency, or rather we leave

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the corresponding losses to the gasworks. Whether it is more economical that they should take place then or in our own boilers depends on the price and quality of gas. At the same time we substitute the higher efficiency of the gas engine for the lower of the steam engine, which may be a very important matter. It is practically equivalent to cutting G out altogether. Still more fascinating are the ideas of obtaining electrical energy direct from steam jets and so doing away with the engine at least, or of consuming our carbon in enormous primary batteries instead of burning it in furnaces, and so at one stroke clearing off boilers, engines, and dynamos. One wishes in vain that one could see ground for any kind of reasonable hope that such methods would be practicable!

Of another kind is the possibility at present much talked of, namely, the substitution not only of a gas engine for a steam engine, but at the same time also of a gas producer for a boiler, so that the motor fluid should be producer gas made on the premises and not steam or coal gas from public mains. There seems no doubt that the combination, although it does not much reduce the number of transformers, gives under certain conditions a very high economy of fuel indeed. I do not think the evidence before us is as yet sufficient, although I hope it shortly will be, to enable us to say how far under ordinary working conditions the actual combined efficiency of the whole plant will be distinctly greater than that of existing systems. The theoretical maximum efficiency, certainly, is much higher. The whole cycle of processes and transformations is shown in Fig. 12, which is drawn so as to compare directly with Fig. 9, and about which, therefore, I need not peak in detail.

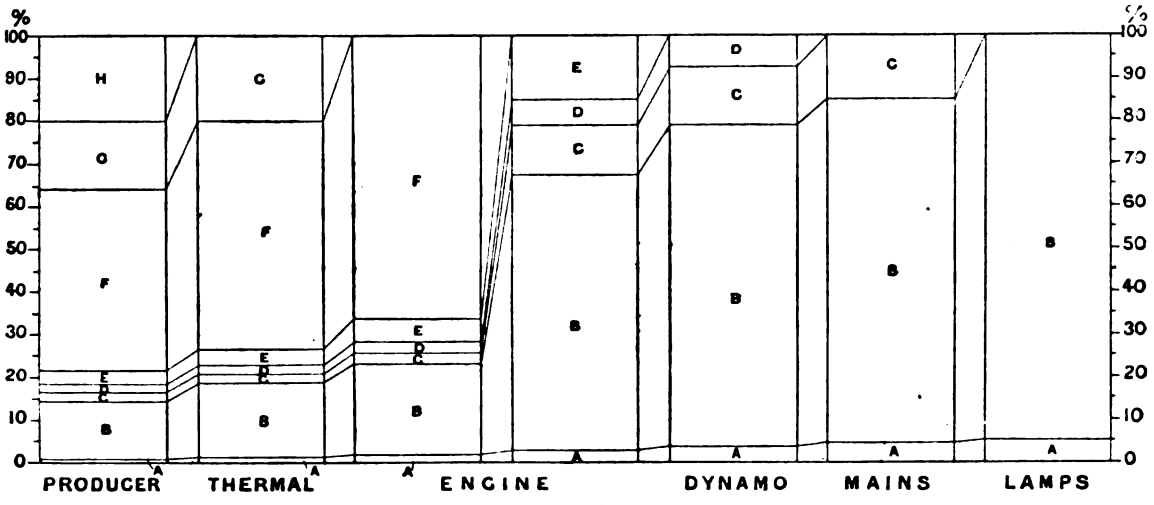


Fig. 12.

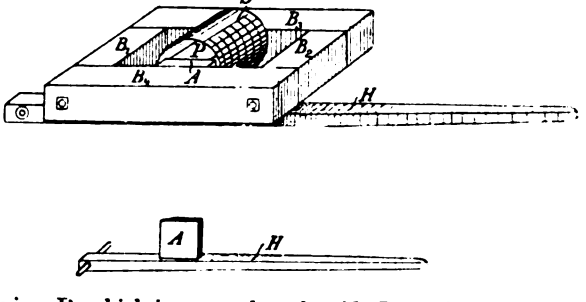
Still one more matter, and I have done. We have heard a good deal lately, from many different quarters, of the enormous possibilities of economy which lie to our hands in the way of utilising as fuel the dustbin and other parish refuse which is now being so largely burnt to waste. Of course this stuff has the vast advantage that it costs nothing, even for cartage, and that at present all the heat due to its combustion is being thrown away. But I cannot help fearing that like most things that cost nothing it will be found to be worth very little more than it costs. I schemed sometime ago the boilers at a station in the North to try the experiment of using waste gases from a town destructor, but have not been sanguine enough to hope that I can do more in this way than save some of the cost of banking fires, or running at very low load. I shall be delighted if I am mistaken in my estimate. In any case it has to be remembered that the dust destructor works on uniformly day and night, delivering a uniform amount of heat, while the boilers of a lighting station want heat non-continuously in most variable fashion. If, therefore, more than a very small fraction of the destructor heat is to be utilised, arrangements must be made for storing that heat somehow, so that it can be drawn upon as it is wanted. With thermal storage there is at least a theoretical possibility of using most of the destructor's heat, without storage 10 per cent. of it is probably the largest amount that can possibly be utilised.

To sum up the whole matter in the way of possibilities and impossibilities, there does not seem to be anything very startling before us in the way of possible economies, except in the two directions of efficiency of lamps as light producers, and of bringing up gas engines to their theoretical maximum. In other respects matters are running along lines which I have endeavoured to indicate, and along which they will doubtless develop more or less rapidly, but always less and less rapidly as they get nearer their limiting efficiency. There is no one point in which we have not some measurements which enable us to set bounds to the possibility of improvement along any known lines, and thus we have means for gauging the value of the pretensions made by each new method, or scheme, or invention, as it appears—not merely guessing at it, but actually estimating its possible value numerically. For those of us who are not born to be inventive geniuses there is always the consoling thought that the difference between good engineering and bad engineering in economy, with the very same materials, is very much greater than the difference between good engineering and any probable improvements upon it. And meantime, we find our hands sufficiently full in trying to keep up to the best existing standards, pending the time when Messieurs the discoverers show us how to get on a little further.

A SIMPLE APPARATUS FOR COMPARISON OF THE MAGNETIC QUALITIES OF SAMPLES OF IRON.*

BY DR. BEHN-ESCHENBURG.

The object of this instrument is to compare the qualities of different kinds of iron as regards induction produced by given forces, and the value of the residual induction. It consists of a rectangular framework made of four blocks of wrought iron screwed tightly together (B_1 B_2), and a coil S, which is slipped on to the



test piece P, which is screwed to the side B_3 of the frame. A small wrought-iron plate A, mounted on a lever H, is so arranged that it fits into the gap between B_4 and P_1, and carries the test coil, which is connected in the usual manner, to a ballistic galvanometer. The values of total and residual induction for a given number of ampere-turns are determined by breaking the current in the coil, and then suddenly removing the plate A.

* From the *Elektrotechnische Zeitschrift*, June 9th.

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The Electrician.

(The Oldest Electrical Journal.)

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny

Editorial, Publishing, and Printing Offices :

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.

Telephone No. 2714. Telegrams : "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co.*"

All Editorial letters to be addressed to the Editor.

All letters intended for insertion in "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as evidence of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. It is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices.*

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ELECTRICAL CONGRESSES AND ELECTRICAL UNITS.

It is generally better, says BACON, to deal by speech than by letter, and the modern mania for congresses may perhaps be taken as an indication that this is so. Congresses, however, like exhibitions have of late fallen into no little disrepute amongst those members of the community who refuse to be "ravished with the whistling of a name." The reason for this is not far to seek. As our dictionaries tell us, congresses are properly assemblies of the delegated representatives of sovereign states for the purpose of considering matters of international importance. Were they always so no healthy minded eupeptic individual would question their utility or quarrel with their pretensions. But now-a-days whenever two or three men of learning or leisure are gathered together they must needs straightway hoist the congressional flag, and do their best to give an odour of international sanctity to their proceedings. There is perhaps no particular harm either in legislation or science by picnic; indeed, "for those that like it, that's the very thing they like." On the other hand, considerable harm is done by giving to any miscellaneous scientific gathering the title of congress, a title which should by rights be reserved for assemblies of official delegates called together, not for the discussion of minute details and the reading of peddling Papers, but to consider matters of international importance and for the solemn ratification of a compact previously arrived at by negotiation or discussion. A congress is not the place for polemical debates or the promulgation of new ideas. As in political so in scientific congresses, the function of a delegate should be narrowed down to securing a general agreement on certain previously discussed points. "Things," says BACON, "will have their first or second agitation; if they be not tossed upon

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the arguments of counsel, they will be tossed upon the waves of fortune and be full of inconstancy, doing and undoing, like the reeling of a drunken man." With a view, no doubt, of preventing the occurrence of anything of this unseemly character at the fifth International Electrical Congress, which commences its labours at Chicago on Monday next, a sub-committee of the American Institute of Electrical Engineers drew up some seven months ago a lengthy and elaborate programme which they recommended should receive its "first agitation" at the hands of the technical journals and at the meetings of the various scientific societies concerned. This certainly was a step in the right direction, and the request for a preliminary discussion was fairly well responded to. The programme, however, was far too ambitious, and contained far too many novelties to be in a fit state for the irrevocable ratification of an International Congress, even after half-a-dozen "agitations." We have been punished for our sins of precipitancy in the past by being dogged for all time by an irrepressible 4π—to remove which certain eminencies would have us recast our entire system of electrical units—and we sincerely trust, therefore, that this programme will not get further than the lower Chamber of the Congress, and that the Congress proper, to wit, the official delegation, will content itself with giving international sanction to the decisions of the Board of Trade Electrical Standards Committee—decisions which embody practically all that the electrical world is really ripe for in the matter of legal units and nomenclature, and which are the net outcome of sixty years of investigation and accurate measurement by the leading men of science of all nations.

This coherent system of electrical units and nomenclature, which, after receiving the *imprimatur* of the Chicago Congress, will become legalised in the leading countries of the civilised world, has not been built up in a day. The foundations were laid by Gauss and Weber in the second quarter of the present century, and the good work was carried on in this country by Thomson, in Germany by Kohlrausch. It was in 1833 that Gauss first published his theory of an absolute system of magnetic measurement, and in 1851 that Weber promulgated the first definite system of current measurement in terms of absolute units. In the same year Lord Kelvin (then Prof. William Thomson) commenced to use the electromagnetic system of units in the reckoning of electromotive force and resistance, and ten years after, in 1861, he obtained the appointment of the historic British Association Committee on Electrical Standards. In 1870 this Committee published its final report at the Liverpool meeting of the Association, and it is this report that may be said to have assured the general adoption of a coherent system of electrical units having for basis the centimetre, gramme, and second. The members of this Committee at the date of the report were:—Prof. Williamson, Sir Charles Wheatstone, Sir William Thomson, Prof. W. A. Miller, Dr. A. Matthiessen, Prof. Fleeming Jenkin, Sir Charles Bright, Prof. Clerk Maxwell, Mr. Chas. Hockin, Mr. C. W. Siemens, Dr. Joule, Mr. Balfour Stewart, Mr. C. F. Varley, Prof. G. C. Foster, Mr. Latimer Clark, and Mr. D. Forbes.

An international system of electrical units is indeed a boon, inadequately appreciated though it may be by a generation that has never known anything else; but an international system of nomenclature is a desideratum of scarcely less importance. Whether the Americans decide to label their arc lamps with the current they require, the energy they consume, or the light they are supposed to give, is a matter of secondary concern so long as the current, energy, or supposititious candle-power is measured in the units adopted by the rest of the world. It would indeed cause a very Babel of units if the American unit of current were ten times as big as its European congener, the American unit of power one hundred times as large, and the American candle a mere farthing dip. But we do not think matters would be appreciably improved if the Americans, whilst employing the same units, were to adopt a narrow patriotic system of nomenclature. In truth, the last state would be worse than the first, with our ampere converted, say, into their "morse," and their "henry" jostling in fierce competition with the Central Institution "secohm" or the Paris 1889 Congress "quadrant." The happy idea of perpetuating the memory of the founders of electrical science by affixing their names to the different electrical units was due, as is generally known, to Mr. Latimer Clark and the late Sir Charles Bright, who first put it forward in a Paper communicated to the British Association in 1861. Both the general idea and the particular names proposed met with world-wide acceptance, and hence we have to day similarity of names as well as uniformity of units.

In 1881 began the era of International Electrical Congresses. The Paris Congress, held in September of that year, sanctioned the adoption of the C.G.S. system and the derived practical units; the names, ampere, ohm, volt, coulomb, and farad being settled upon. It was also decided that the standard of resistance should be a column of mercury of one square millimetre cross-section, the length of the column to be determined by an international committee to be appointed. Amongst the English delegates at this the first International Electrical Congress were Earl Crawford, Sir Charles Bright, Prof. Hughes, Sir William Thomson, Mr. Warren de la Rue, Sir William Siemens, Mr. Graves, Mr. Preece, and Prof. W. Grylls Adams. In May, 1884, Paris was again the scene of an International Electrical Congress, the main outcome of its labours being the adoption of the so-called legal or 106-centimetre ohm and the Violle standard of light, neither of which met with much enthusiasm. Electrical energy was apparently overflowing in 1884, for in the autumn of the same year there was another gathering of electricians at Philadelphia. This assemblage was called a Congress, although there were no official delegates, and the pernicious and uncongressional practice of reading miscellaneous Papers and discussing them was not only permitted but encouraged. At this meeting the "watt" was born, the Violle standard of light was denounced as impracticable, and the engineering world ordered to raise the value of the horse-power by 33·3 per cent. in order to make it equivalent to 1,000 little watts, and thus save the time and temper of calculating electricians. It is satisfactory to find that this journal raised a gentle protest against that ukase, and meekly hinted that it made the Congress look a trifle ridiculous. The next so-called Congress was held in Paris during the Exhibition of 1889. Official delegates there were none, but officious delegates there were many, who endeavoured to secure amongst other absurdities a congressional decree to the effect that the unit interurban telephonic conversation should be one of three-minutes' duration. At this meeting the "secohm" received its *quietus* and the "quadrant" reigned in its stead; the watt was again adopted as the unit of power with the kilowatt as its commercial derivative; the joule was sanctioned as the unit of work, and the "bougie-decimal" was accepted as the practical unit of light. The passing of the Electric Light Amendment Act of 1888 having resulted in a great extension of the system of statutory electricity supply from central stations, *legal* standards of measurement were soon felt to be necessary, and on December 16, 1890, the Board of Trade appointed a Committee to consider the question. The first report of this Committee

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was dated July 23, 1891, the second was dated November 29, 1892. The purport of these reports is too well known to need recapitulation; suffice it to say that they recommended the *legalisation* of the electromagnetic system and the adoption of a standard ampere, ohm, and volt; the resistance of one ohm to be represented by that of a column of mercury at 0°C 106·3 centimetres long, of constant cross-section, and weighing 14·4521 grammes. As soon as the resolutions of this Committee have received the international sanction of the Chicago Congress, the electromagnetic system with its practical derivatives and their quaint nomenclature, will become crystallised for all time by the legislative acts of the nations of the civilised world.

THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 397.)

It will thus be understood that the ratio of the cold resistance to the hot resistance of a flashed filament depends entirely on the ratio of the amounts of the two kinds of carbon of which it is composed, a much-flashed filament having a larger ratio than one only slightly flashed. The resistance of a filament measured cold gives no indication of its hot resistance unless that ratio is known. The most usual ratio is about two to one, though it is often above or below that amount. The specific resistance of arc-lamp carbons (cold) will vary from 13,000 microhms per c. c. to less than that of amyloid, according to the method of manufacture, moulded carbons having a higher specific resistance than squirted ones.

Different kinds of carbon have different emissivities; that is, they radiate heat and light at different rates, so that, at a given temperature, carbons of the same size but of different makes require different amounts of power expended in them in order to maintain that temperature. This curious property appears to be connected with the nature of the surface only, and has nothing to do with the material underneath the surface.

It is well known that a hot polished copper rod, if covered with lamp black will cool much more rapidly than a similar rod not blackened. In the same way a hot lamp filament with one kind of surface will cool faster than a similar filament with another kind of surface. A filament made of amyloid carbon will cool faster than the same filament if it be flashed in pentane in the way described. Suppose that an amyloid carbon filament be made into a lamp and tested, and that it is found that at 4 watts per candle power it takes 84 watts and gives, consequently, a light of 21 candles. Let the same filament be taken out of the lamp and flashed a very little by the pentane process and then be made into a lamp again and tested. Let it be run at the same temperature as before, and it will be found to give only 15 candles and take only 60 watts. Now that it is flashed and has a different kind of surface it loses heat much more slowly, and a less expenditure of power suffices to maintain it at the former temperature. It must be particularly noticed, however, that there is a corresponding decrease in candle power. Let it be run at its original candle power (*i.e.*, 21) and it will be found to take about 68 watts, equal, that is, to about 3¼ watts per candle, considerably less power than before flashing. Many people have supposed that results like this indicate that the flashed filament is a more efficient one than the unflashed. This, however, is not the case at all. The filament now giving 21 candles is at a higher temperature than it was when giving that candle power before being flashed. If it had not been flashed at all, it could have been equally well run at this temperature and efficiency, only it would then have given about 28 candles and have taken about 90 watts. The filament has simply become less emissive. It radiates more slowly.

The extent of surface of filaments will vary with different kinds of surfaces from 6,000 to 10,000 square mils per candle power at the temperature of 4 watts per c. p. (equal to 100 to 170 c. p. per square inch). When run up to the temperature at which the best carbon begins rapidly to disintegrate (0·8 w. per c. p.) as much as 1,900 c. p. per square inch may be reached. The crater of an arc-lamp carbon is said to give about 45,000 c. p. per square inch.

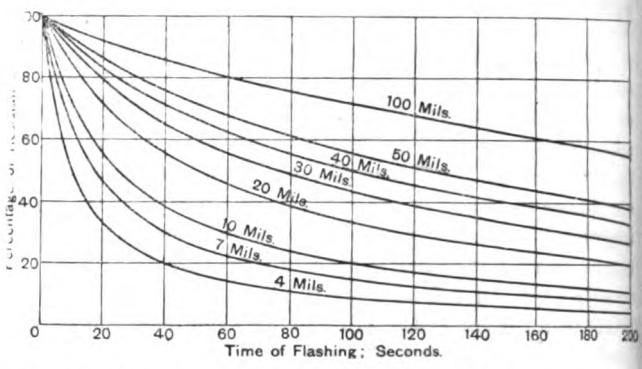

FIG. 16.—Curves showing Effect of Flashing on the Resistances of Filaments of Various Diameters.

The change in emissivity produced by flashing gives an additional reason for carefully reproducing the conditions under which that process is carried out for each filament so that they may all come out alike.

The actual amount of the error in the voltage of the lamps produced by the several causes mentioned will now be considered.

An error in the thickness of a filament is a serious one. Suppose that a filament for 100-volt 15-c. p. lamp at 4 w. per c. p. (= 60 w. total) should be 6 mils in diameter, but that the conditions of flashing have not been quite right, so that the diameter comes out at 6·4 mils, an increase of 6·6 per cent. in diameter, and therefore in surface. The filament will now

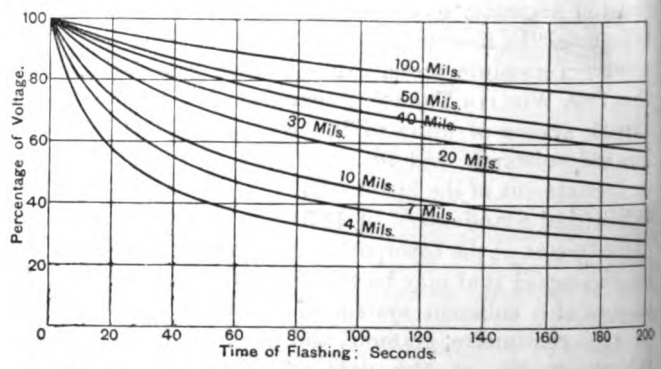

FIG. 17.—Curves showing Effect of Reduction in Resistance, due to Flashing, on the Voltage of Filaments of Various Diameters.

require 6·6 per cent. more energy, and will be increased a like amount in c. p. It will take 64 watts and give 16-c. p. But it was flashed to the resistance for a 15-c p. lamp (166 ohms.) not for a 16-c. p. one. Consequently, it will take 103·2 volts and 0·62 ampere, to give the right temperature. Or if run at 100 volts it will give only about 13·5 candles, and an efficiency of 4½ watts per c. p.

It will be noticed that, though the increase in diameter is 6·6 per cent., the increase in voltage is only about half that amount, the error being divided between the E.M.F. and the current. The percentage error in voltage will be about one-half that of the diameter for ordinary variations.

With regard to errors in emissivity due to the conditions of flashing being wrong, the effect is exactly the same as for

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errors in thickness, an increased emissivity having the same effect as an increase in diameter. A similar result will be produced if filaments are mounted with wrong lengths. This is usually looked upon as a less serious matter than differences in thickness, as it is supposed to be easy to mount filaments to the proper length. Suppose a filament is to be five inches long. One per cent. is 0·05 inch. That is to say, it must be mounted with an error of not more than 0·025in. on each leg, in order to be within 1 per cent. It is, therefore, very important to be exact in the matter of length.

With errors of resistance the same kind of result occurs as with errors in surface. One per cent. error in resistance will produce only about one-half per cent. error in voltage. This

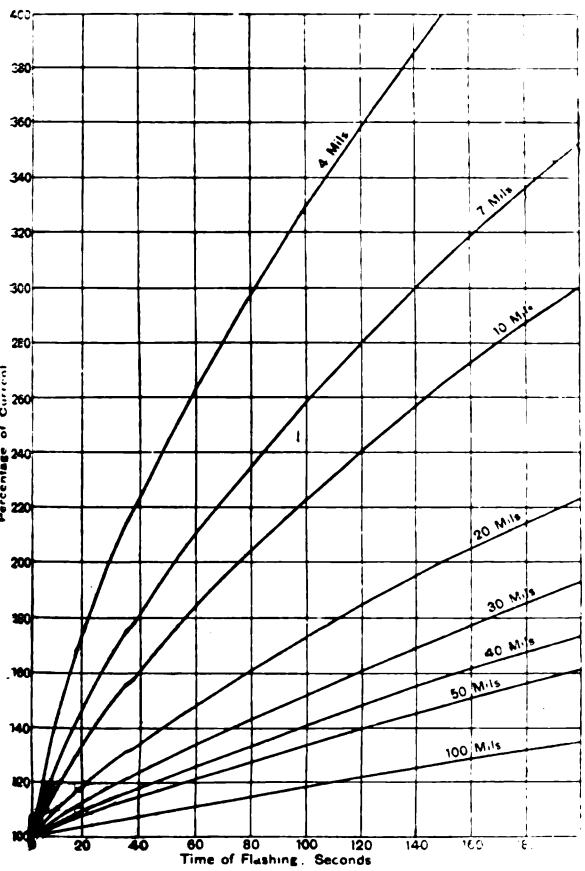

Fig. 18.—Curves showing Effect of Reduction in Resistance, due to Flashing, on the Current for Filaments of Various Diameters.

must not be understood to apply to very large differences in resistance. For instance, a 50 per cent. reduction in resistance gives more than 25 per cent. reduction in volts. The actual effect on the volts and current of a gradually diminishing resistance is shown in the accompanying curves, Figs. 16, 17, 18. The resistance is supposed to be diminished by flashing, the thickness of the deposit of flashed carbon being considered as proportional to the time of flashing, the rate of flashing being such that a 4-mil filament is reduced 50 per cent. in resistance in ten seconds.

It must be understood that the effect of reduction in resistance alone is shown in these curves. The actual results of flashing, taking into consideration the change in resistance, emissivity and thickness are fully dealt with in a subsequent chapter.

It has been shown that the time of flashing is an important consideration, and that it is better to flash always to about the same length of time and use filaments of different diameters, which will permit of this being done, than to use only a few sizes of filaments and vary the time of flashing.

It is therefore necessary to consider the relation of the sizes of filaments to the candle-power, voltage and temperature at which they are to be run.

(To be continued.)

LORD KELVIN'S NEW ELECTRICITY METERS.*

BY ANDREW W. MEIKLE, M.A.

In 1887, Lord Kelvin reported to the Society regarding the progress of his work upon electrical measurement, in a Paper entitled "A Double Chain of Electrical Measuring Instruments." Since that time much has been done to improve and complete the *chains* then spoken of, and they now form the recognised standards in all parts of the world. The chain of balances has been extended, and now affords a means of accurate measurement from $\frac{1}{100}$th to 10,000 amperes. The chain of electrostatic voltmeters has been made to suit all ranges from $\frac{1}{100}$th of a volt to 150,000 volts. Besides these two types of standard instruments, others have been made to suit the requirements of power and light installations. These are made mostly on the plan of the ampere gauge (Fig. 1), which has actually been constructed to suit all ranges between $\frac{1}{4}$th of an ampere and 15,000 amperes. Some special instruments have been designed, from time to time, to suit various requirements, and I am pleased to be able to show the Society an instrument designed for the Edison Electric Illuminating Company of New York, and which is, without doubt, the largest voltmeter in the world. I will describe it later on.

I now wish to describe another chain of instruments which are intended to record the amount of electrical energy consumed in a power or light installation. The instrument consists of an electrically-driven clock, and of an electric indicator which shows the

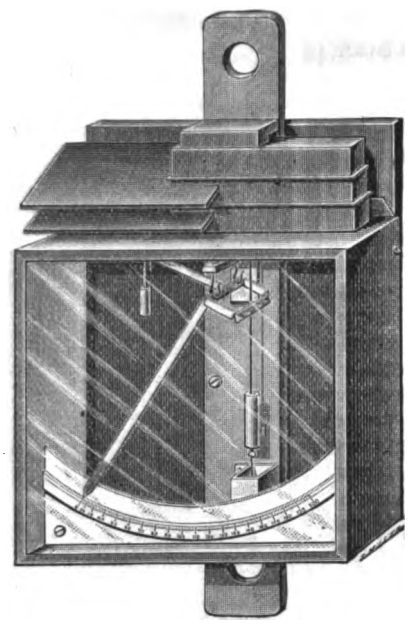

Fig. 1.—Ampere Gauge.

strength of the current passing at any particular moment. This instrument is shown in Fig. 2, and details are given in Figs. 4, 5, and 6.

Before entering into these details of this instrument, as a recording meter, I shall first describe the electrical indicator, and afterwards give a description of the indicator and clock, as forming a recording electricity meter.

The electric portion of the meter consists of two parts—

1. A main coil, D (Figs. 5 and 6), which carries all the current supplying the lamps.

2. A movable electromagnet suspended upon two spiral springs (Figs. 4 and 5.)

The main coil has a number of turns of copper rod wound as shown in Figs. 5 and 6. The number of turns and thickness of the rod vary according to the current range of the meter; thus, a meter for 25 amperes has about 75 turns in its fixed coil, while a meter for 250 amperes has only eight or nine turns of heavier conductor. In the earlier forms of the meter the coils were made of a stranded conductor formed of a number of silk-covered wires, but the present form of coil has many advantages. It has its surface open to the air, and so quickly radiates off the heat generated by the passage of the current. It has also the advantage of giving a more intense field for a given cross section of conductor, because the whole conductor lies nearer the axis of the solenoid than it does in the stranded coils, the latter losing in concentration by the thickness of insulation on its different wires.

* A Paper read before the Philosophical Society of Glasgow.

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The electro-magnet consists of a soft-iron bar, on which are rolled a great number of turns of very fine insulated copper wire. Soft iron is used in order to obtain sufficient force to overcome all frictional errors. The same phenomena could be obtained by the action of the main solenoid upon another solenoid of fine wire, but the force would be very feeble; this would also be the case if a permanent steel magnet were used. By the use of soft iron the force is increased more than 2,000 times over what it would be if a fine wire solenoid only were used. There is nothing new, of course, in the use of soft iron and a solenoid in electrical instruments. Many instruments have been made depending upon this principle, but most of them have not been very successful, because of errors due to residual magnetism in the soft iron. These errors are due to the fact that, if we magnetise a piece of soft iron and remove the source of magnetism, the iron will retain some of the imposed magnetism until it receives some shock or jar, when it returns at once to its original state. That is only the case with a piece of good soft iron; a piece of iron which is not thoroughly annealed will retain its magnetism in spite of a shock, and the amount of the residual magnetism is a very varying quantity, so that no good result can be obtained from it. This trouble in measuring instruments can be got over well enough for practical purposes by choosing the iron of suitable dimensions and using a very intense magnetising field. Lord Kelvin has done this in his engine-room ampere gauge (Fig. 1), in which he uses a solenoid of special construction, which gives a very intense field, and a soft iron plunger, which has a ratio of diameter to length of about 1 to 200. A bar of these dimensions is very easily saturated, so that it is found possible, with this instrument, to get a useful range free from residual errors of about 1 to 10. That means that an instrument suited to read to 100 amperes could not be used below 10 amperes, because it would show considerable uncertainty, and would not be sensitive. In this meter it is absolutely necessary that the scale throughout should be uniform—that is to say, that the electro-magnet should be pulled down a distance exactly proportional to the strength of current. It is found impossible to use the fine wire solenoid alone, because there is too little force to overcome the friction of the plunger on the side of the coil, and too delicate springs would require to be used. It is found impossible to use soft iron alone, because it does not give a uniform scale, and would be subject to the errors just mentioned. What is done, then, is to use a bar of soft iron, which is kept saturated by the current through the fine-wire coil wound upon it. The current through this coil is about $\frac{1}{40}$th of an ampere, and this is about 25 per cent. more than is sufficient to keep the iron fully saturated, and makes it for the purpose virtually a permanent magnet. This is, I think, quite a new departure in measuring instruments, and allows much greater masses of iron to be used with good results, and also enables a large range to be had from one instrument.

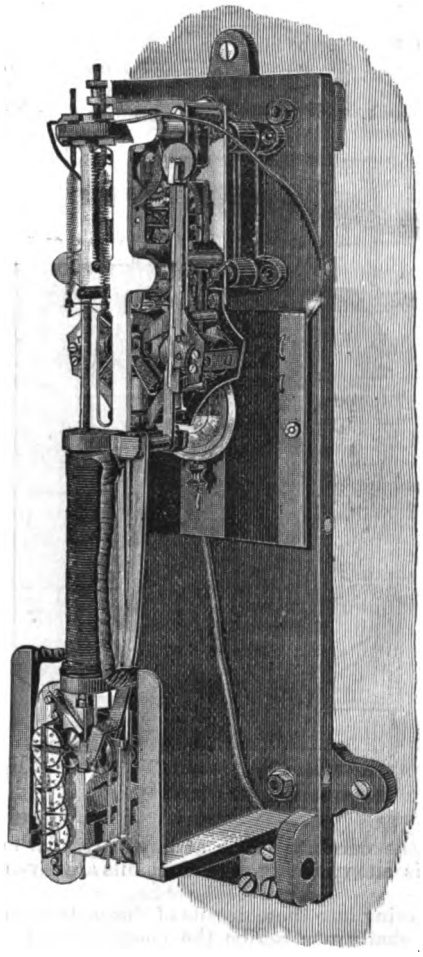

FIG. 2. Electricity Supply Meter.

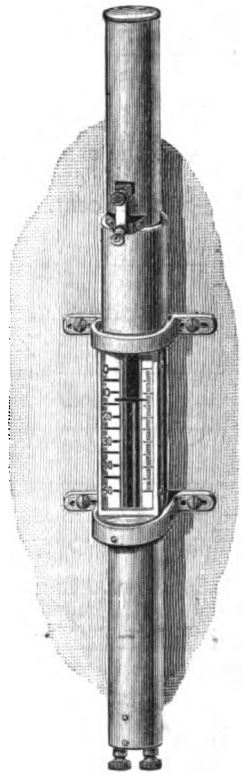

FIG. 3.—Tubular Ampere Gauge.

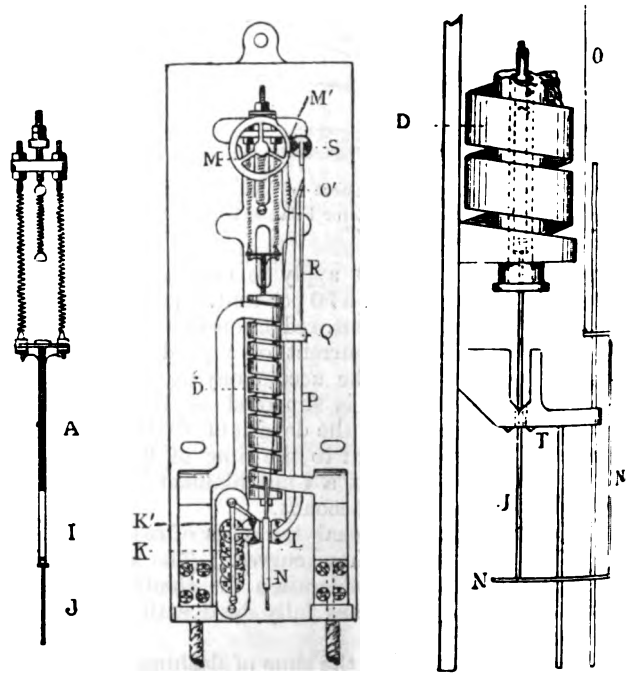

FIG. 4. FIG. 5. FIG. 6.

Details of Electricity Supply Meter.

In an instrument called the Tubular Ampere Gauge, made as now described (Fig. 3), a scale of equal divisions is procured from 0 to 50 amperes, or from 0 to 100 amperes, as will be seen. An instrument of this kind is very useful in a dwelling house, or other installation, where it is desirable to know if all the lamps have been put out, or what number of lamps are in action.

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Having now described the principle of the electrical indicator, I ll speak of the details of the combination which forms the meter. ıe details are shown in Figs. 4, 5, and 6. The suspended electro- ıgnet is shown separately in Fig. 4.

At the bottom end of the electro-magnet, A, is attached a guiding be, I, and a loose bar, J, hangs on a projecting ring in the bottom the guiding tube. This loose bar hangs betwen two rollers, K′ d L (Fig. 5), which have broad, flat rims. The range of the

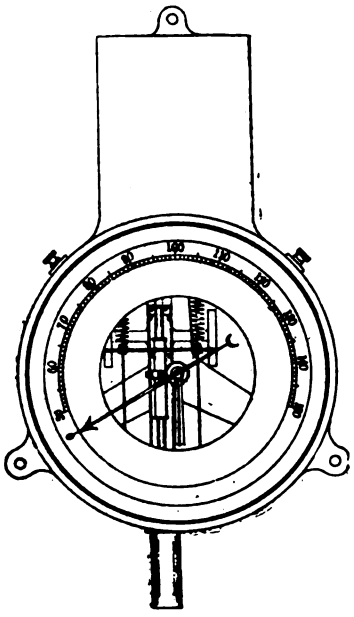

FIG. 7 Large Dial Voltmeter. External View.

ctro-magnet, A, is fixed by stops, and the end of the bar, J, is guided that it cannot be thrown out from between the rollers, and L. At periodic intervals of time, the roller L, is by a rolving cam, M, caused to press the bar, J, against the roller, K′, d at the same time, and actuated by the same cam wheel, M, a atform, N, is lifted till it touches the lower surface of the cheeks, (Fig. 6), and lifts up the bar, J, and causes the roller, K′, of the unter to turn through a space proportional to the amount of rrent passing through the fixed coil, D.

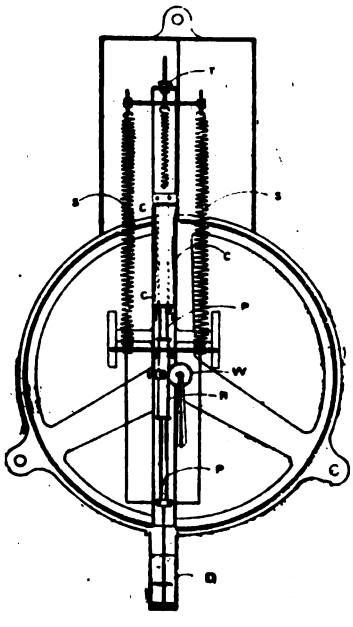

FIG. 8.—Large Dial Voltmeter. Internal Arrangements.

The zero position of the electro-magnet, A, is adjusted so that e extreme end of the bar, J, just touches the platform, N, when e latter is drawn up against the lower surface of the guiding eek, T. The cam wheel, M, is kept revolving uniformly by ckwork, and has attached to it a stud which carries the platform, by a connecting wire, O, having a small spiral spring, O′. As e cam wheel revolves, the platform, N, is lifted till it presses ainst the lower surface of the guiding cheeks, T, and lowered till it is below the lowest possible position of the rod, J, by the rising and falling of the stud, M′. The roller, L, is pivoted to a rod, P, attached to a crosspiece, Q, which is pivoted to the framework of the instrument. Also attached to the crosspiece there is another spring rod, R, which carries a roller, S, which is kept in contact with the cam wheel. While the portion of the cam wheel, which is of larger radius, is passing the roller, S, the roller, L, is pressed forward, and the loose piece, J, is nipped between the rollers L and K′. At this time the platform, N, is at the bottom of its range.

If a current is passing through the fixed coil, D, the electro-magnet, A, and consequently the bar, J, are pulled down by a corresponding amount, and the platform, N, in its upward motion carries the bar, J, back to its zero position, at the same time turning the rolling wheel, K′. When the platform, N, first touches the lower surface of the guiding cheeks, T, the stud on the cam wheel is not quite at its highest position, and while it rises to it the spring, O′, is elongated. When the stud begins to fall the spring contracts, and at the same time the bar J, is unclamped from between the rollers, K′ and L, so that by the time the platform, N, begins to fall, the bar, J, is hanging quite free. When no current is passing, the bar is clamped at its zero position, and the platform, N, on being lifted, touches the end of the bar and the lower surface of the guiding cheeks at the same time, and no record is made on the roller, K.

Description of Large Dial Voltmeter for the Edison Electric Illuminating Company, of New York.

This instrument depends for its action upon the pull of a solenoid, C, on a suspended electro-magnet, P. Fig. 7 gives an external view, and Fig. 8 shows the internal arrangements of the parts. P is a plunger of soft iron about 60 cm. long, and about 1 cm. in diameter, which has a coil of about 30,000 turns of fine wire wound on it. The current is conducted into and out of this circuit by means of two spiral springs, SS, which also serve to support the weight of the electromagnet. The resistance of this circuit is about 1,500 ohms, and it is found that a current of one-twenty-fifth ampere is sufficient to saturate the iron, so that from 60 volts upwards a scale is obtained free from "residual" errors. The electromagnet is suspended, with its upper pole entered about three diameters inside the main solenoid, C, at zero position. T is a screw for adjusting the zero of the electromagnet. Attached to the electromagnet is a rack, R, which is geared into a pinion wheel, W, on a shaft carrying the pointer. When a current is passed round the solenoid, C, the electromagnet is pulled up, and so turns round the pinion wheel and hand. The scale, after the plunger is saturated from 60 volts upwards, consists of equal divisions. A rod, carrying two discs, is screwed into the lower end of the electromagnet, and the discs, working in thick oil in a dashpot, D, serve to damp vibrations due to sudden changes of E.M.F. The diameter of the dial is about 30 inches.

NOTE ON THE COMPARATIVE EFFECTIVENESS OF DIFFERENT TYPES OF LIGHTNING GUARDS.*

BY E. MASSIN.

Electric lines have multiplied tremendously in France on account of the development or creation of numerous telephonic networks, and the proper protection of the apparatus which are used on these lines becomes every day of more and more importance. In the *Annales* for September-October, 1887, and for January-February, 1889, M. Lagarde described a method devised by him for comparing the effectiveness of different types of lightning guards. But although he published the results obtained, M. Lagarde points out the defects of his method. The absolute results are not comparable for different series, owing to "the inconstancy of the batteries actuating the induction coil, variations in the hygrometric condition of the surrounding air, and the other causes that influence the electric charge of a body electrified to such a high potential." A close investigation of the question and a series of preliminary experiments enabled me to see—first of all, that a large induction coil could not without injury furnish continuously for several hours at a time sparks 35 to 40 centimetres long; secondly, that whatever precautions were taken the causes of error indicated by M. Lagarde were unavoidable; and, lastly, that owing to the impossibility of always producing identical charges the classification of the same set of lightning guards in order of merit, frequently varied from one series of experiments to another. It therefore seemed necessary (1) to make use of another source of electricity, (2) to no longer examine how two lightning guards behaved under the action of two identical discharges; but, on the contrary, to compare the simultaneous behaviour of two lightning guards towards the same discharge.

* From the *Annales Télégraphiques.*

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The Source of Electricity.—A 0·03 ϕ Leyden jar charged by a Wimshurst machine was decided on as a source of electricity. The Wimshurst machine gave sparks of from 0·15m. to 0·20m. under good hygrometric conditions. Owing to the enormous electric pressure employed there were considerable losses in the apparatus composed by the jar and the machine, and to prevent the electricity furnished by the machine from serving after a few turns to merely make good these losses it was as well to make the quantity of electricity furnished as high as possible, and to run the plates of the machine at a high speed. For this purpose three little electric motors arranged in parallel and absorbing 150 watts were employed, giving the plates a speed of 1,200 revolutions. The discharge produced by short-circuiting the jar after a minute's charging produced a spark that appeared to be 8 to 9 centimetres in diameter, and burst with a noise painful to hear. On the other hand, when the jar was discharged through the connections and the experimental apparatus, to be described, the spark was decidedly less violent, and seemed to be only 5 or 6 centimetres in diameter. The conductors employed to make the connections consisted of a cable insulated by a triple layer of gutta-percha. All crossing of the wires was avoided. The wires that connected the jar and the apparatus at certain moments and that were then at an enormous difference of potential, were carried on stretched pieces of string 5 metres long, and were kept at least 50 centimetres apart (*see* Fig. 1). If the conductors were left only a few centimetres apart we heard the crackling of the discharge passing through the pores of the gutta-percha.

Experimental Arrangement Adopted.—In Fig. 2, 1 and 2 were the lead and return cables which came in on to the machine on a large glass tube forming the two branches of a discharger, the handle of which was formed by the glass tube. The positive cable divided at A into the two identical circuits B C D K and B′ C′ D′ K. B and B′ being the two lightning guards to be tested, C C′ being two fused-wire guards protecting the two 500 ohm bells D and D′. The two circuits united at K on the return wire 2. The terminals of D and D′ were connected by "indicators" E and E′, consisting of a plate towards which a platinised screw could be brought up. The head of the screw was divided into 72 equal parts, and the pitch of the screw was about 0·73mm., so that each division corresponded

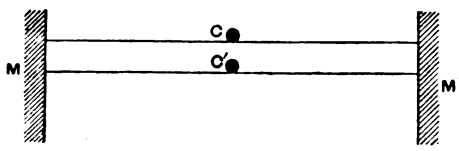

FIG 1

to about 1/100th of a millimetre. It is evident that the larger the quantity of electricity going through D the larger, all things being equal, will be the spark at E. Now, the circuits A B C D K and A′ B′ C′ D′ K are identical, and represent actual installations; if, therefore, the "indicators" E and E′ are properly adjusted the relative values of the sparks at E and E′ will give the relative effectiveness of the two lightning guards B and B′ in respect of the same discharge. To adjust E and E′ the cables 1 and 2 were connected to the poles of a battery, the bells rang, and the screw of E was turned until it came into contact with the plate, when the short-circuited bells were silenced. The screw was then screwed back n divisions. This number n depended on the effectiveness of the lightning guard tested. The same process was gone through for the "indicator" E′, the same number n being chosen. There was now a first approximation, which could be altered if necessary in the course of the experiment.

Mode of Carrying Out an Experiment.—An experiment was carried out as follows:—The jar was charged for a period t; the free ends of the cables 1 and 2 were then suddenly brought up to the coatings, a discharge occurred, and divided itself between the two circuits, part escaping through the lightning guards B and B′, the rest through the bells D and D′ and the indicators E E′. The indicators E and E′ being arranged one beside the other in a dark room, it was easy to determine the relative value of the sparks occurring in them. The circuit was then tested by means of the battery, and the experiment begun over again. If, after a series of discharges, the superiority of the sparks at indicator E, for example, was ascertained, this could only be due either to the inferiority of the lightning guard B or to a faulty regulation of the indicators. To settle the question the lightning guards B and B′ were interchanged, and the superiority passed from indicator E to indicator E′; if not, it was the adjustment that was wrong, and it was modified.

Successive trials always led to the conclusion that the lightning guard connected with the indicator giving the biggest sparks was inferior to the other, since it allowed a larger quantity of electricity to reach the corresponding coils. When the lightning guards to be compared are very good, the indicator has to have a very small gap to allow a discharge to take place, and in some cases it is necessary to have only a gap of 1/100th of a millimetre between the platinised point and the opposite plate. The adjustment of the indicators is a somewhat delicate matter when the lightning guards to be compared are but slightly different, and at times it requires several hours to secure a good adjustment and obtain well-marked results. This method enabled me to obtain identical results at the beginning and at the end of the same day, as well as at different times, so that there is some reason to consider it effective.

Tests were made on air-gap lightning guards—two-plate, two-comb (Bertsch), and plate and comb—on corrugated lightning guards, and on lightning guards with paper, gutta-percha, or mica insulation.

Air-Gap Two-Plate Lightning Guards.—The effectiveness of a lightning guard of this class is independent of its surface, and only depends on the length of the air-gap and on the degree of polish of the plates. It was impossible to discover any difference in the case of two air-gap lightning guards, of which the area of the plates was identical, and of which the area of one was four times that of the other. On the other hand, it was easy to show the inferiority of a lightning guard that had received a certain number of discharges to an identical one, the plates of which had just been polished. For instance, an air-gap lightning guard which had just been cleaned, and had a gap of 73/100ths of a millimetre, was found to be identical with a lightning guard which had already been used and had a gap of only 50/100ths of a millimetre. On polishing the plates of the latter instrument it was necessary to give it a gap of 75/100ths of a millimetre before equivalence was restored.

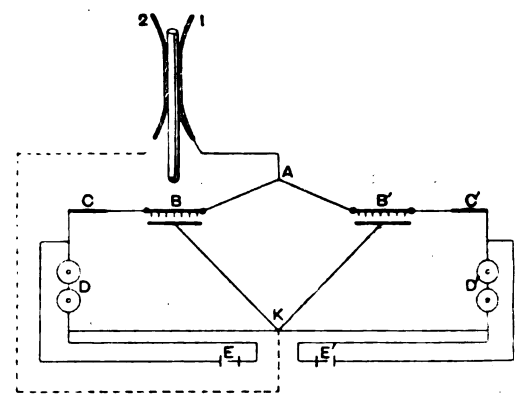

FIG. 2.

As a result of these preliminary experiments the air-gap two-plate protector was taken as a standard of comparison. It was made as follows:—A plate resting on four supports and connected to earth; above it a second plate connected to line, and resting on two set screws, the distance apart of the plates being varied by means of washers (*see* Fig. 3).

Air-Gap Comb Lightning Guard.—With the points 1mm. apart this type is equivalent to a plate protector with a 1mm. air-gap. Equivalence almost holds up to a gap of 8/10ths of a millimetre. For 5/10ths of a millimetre the effectiveness was found to be between that of a plate protector of 5/10ths and 6/10ths of a millimetre. This difference is within the errors of experiment.

Plate and Comb Air-Gap Lightning Guard.—The type tested had a gap of 8/10ths of a millimetre between comb and plate; it was equivalent to a 12/10mm. plate protector. This difference may be explained by the condition of the surface of the plate, which left much to be desired.

Insulating-Sheet Lightning Guard.—With a 7/100mm. sheet of paper, taken from a block of telegram forms, the effectiveness of the protector was the same as that of 40/100mm. air-gap protector. The protection was then very complete, and it was necessary to bring the point of the indicator to within less than 1/100th of a millimetre of the plate to obtain a spark. The paper was perforated at each discharge either by a single hole attaining 3mm. diameter, or by two or three or several holes of less diameter, showing a many-path discharge. It may be useful to note also the difference in the mechanical effects in the case of paper-sheet and air-gap protectors. In the former, one sees well-defined punctures like pin-points surrounded by a brown discolouration. In the latter, one only sees a spot; and it may be asked whether the paper-sheet protector does not deteriorate more rapidly than the air-gap protector under the influence of discharges.

If the insulating sheet consists of paraffined paper, the effectiveness is about the same as if the paraffined paper were replaced by two or three sheets of the same kind of paper having the same total thickness, with a slight difference always in favour of the non-paraffined paper.

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The gutta-percha sheet lightning-guard of 6/100mm., used by the Telegraph Department, corresponds to an air-gap protector of 170 100mm. If we replace the gutta-percha by a sheet of mica 8 100th of a millimetre thick, its effectiveness is only equal to that of an air-gap plate protector of 200/100mm.

Corrugated Lightning Guards.—In the lightning guards of the Telegraph Department type used in the postmen's call-bell circuits, the planes of the corrugations are 45 100th of a millimetre apart. Such a protector when new is equivalent to a 80/100mm. air-gap plate protector. This lack of effectiveness is due, no doubt, to the state of the opposed surfaces which are not polished.

Conclusions.—The effectiveness of air-gap plate protectors only depends on the distance apart of the metallic plates and their degree of polish. Nevertheless, it is found with this type of lightning-guard that when the gap is only 3/10th to 4/10th of a millimetre the line is put to earth, probably by condensation momentarily short-circuiting the two plates thus brought so close together. The air-gap comb protectors are comparable with the plate protectors. Their construction, it is true, is much more complicated, but

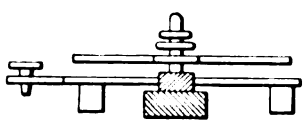

Fig. 3.

they do not seem to be liable to short-circuiting, as mentioned above. Moreover, they have the additional advantage of quietly dissipating, by means of their points, a charge that has not sufficient potential to spark across, a fact which is easily shown to be the case. As to insulating-sheet protectors, it is necessary to eliminate gutta-percha and mica, and to adopt paraffined-paper protectors, the paper being as thin as possible. Paraffined paper is not hygrometric like ordinary paper, and its effectiveness can be made comparable to that of air-gap plate protectors, in which the distance apart of the plates is such that short circuits would be established spontaneously. The sheet of paper ought not to be, it must be pointed out, either softened (*éridé*) or cut (*découpé*); if it is we come back to an air-gap plate protector. Air-gap comb protectors with small gaps or paraffined-paper protectors, are the very ones used in practice, and, as well as in the case of air-gap plate protectors, it is well to point out the defects of the protectors which seem the best. These two kinds have their advantages and disadvantages, the first seems the more thorough and does not require manipulation every time it has been traversed by a discharge, but the second can be installed at much less cost than the first.

ELECTRO-OPTICS.*

BY A. B. BASSET.

The experimental and theoretical investigations of the last twenty years have lent a new interest to what, I venture to think, is one of the most fascinating branches of physical optics, namely, the action of an electromagnetic field upon light. The discoveries which have hitherto been made may be classified under four heads: (1) Faraday's experiments, which show that when plane polarised light is transmitted through a *transparent* magnetised medium, a rotation of the plane of polarisation is produced; (2) Kerr's experiments, which show that the effect of electrostatic force on a *transparent* medium is to convert it into one which is optically equivalent to a uniaxal crystal whose axis is in the direction of the force; (3) Kerr's experiments on the reflection of plane polarised light at the surface of a magnetised iron reflector, which show that a rotation of the plane of polarisation of the reflected light takes place, which in certain cases is in the same and in others in the contrary direction to that of the amperean current, which may be conceived to produce the magnetic force; (4) Kundt's experiments on the reflection of light from magnetised iron, cobalt, and nickel, and also on the transmission of light through thin magnetised films of these metals. There is also another series of experiments by Kundt, in which polarised light is refracted at the upper surface of a plate of glass, is then reflected at the lower surface, and again refracted at the upper surface. The results of these experiments show that the plane of polarisation of the ultimately-emergent light is rotated in the *contrary* direction to that produced by an iron reflector.

There seems to be a fair amount of evidence to lead to the conclusion that Hall's effect is intimately connected with the action of a magnetic field upon light, but further evidence is required before it can be asserted that both phenomena are due to the same ultimate cause. Up to the present time Hall's effect has, I believe, only been detected in conducting media; but if it be assumed to be capable of existing in transparent media, theory furnishes results which, as far as they have been worked out, are in agreement with experiment. Hall's effect is capable of explaining the experiments of Faraday, and it also gives a result in accordance with Kundt's experiments on reflection and refraction from a plate of magnetised glass in the case in which the magnetism and incidence are normal. It would be quite possible to apply this theory to the case of oblique incidence, but the work would be laborious and the final results complicated. The experiments of Prof. Dewar on liquid oxygen would seem to provide a more promising way of testing this theory, for, on account of the high susceptibility of this substance to magnetic action, it is possible that an effect might be observed in the case of *direct* reflection.* According to theory, Hall's effect ought to be positive in the case of glass and gaseous oxygen, and negative in the case of a solution of perchloride of iron; and a repetition of Kundt's experiments, in which the latter liquid is employed in the place of glass, ought to show that the rotation takes place in the *same* direction as that produced by metallic iron. Such experiments would be valuable as a further test of the theory, but they do not appear to have been made.

A Paper recently communicated to the Cambridge Philosophical Society (May 1st) still further confirms the view which I have put forward. In this Paper I have transformed the formulæ for reflection at a magnetised *transparent* medium by assuming that the refractive index is a complex quantity. The resulting formulæ for the amplitudes of the reflected vibrations agree very well with Kerr's experiments so far as qualitative results are concerned, provided the values and signs of certain quantities are supposed to be determined by optical, as distinguished from electromagnetic methods. They are, moreover, the same *as regards their form* as those deducible from Maxwell's theory by taking into account the conductivity combined with Hall's effect; but unfortunately the values of certain constants, when expressed in terms of electrical quantities, differ from the values which are required by optical experiments, in a manner which prevents a perfectly satisfactory electromagnetic theory being constructed in this way, and I doubt whether it will be possible to attain the end in view until a theory based upon the mutual reaction of ether and matter has been discovered in which quantities, upon which the motion of matter depends, enter into combination with electromagnetic quantities.

Although the sign of Kerr's effect in nickel is the same as in iron and cobalt, the sign of Hall's effect is different. This difficulty is apparent rather than real, for a theory based upon the mutual reaction of ether and matter might very well introduce a factor containing the free periods of the vibrations of the matter which would change the sign of the magnetic terms. Some light might be thrown on this point by determining the principal incidence and azimuth for nickel and cobalt.

The generally received theory, that reflection and refraction are materially influenced when any of the free periods of the vibrations of the matter fall within the limits of the visible spectrum, suggests that the sign of Kerr's effect may be different in the case of the ultra-violet and the infra-red portions of the spectrum from what it is in the luminous portion. Experiments on this branch of the subject are needed, and possibly the employment of a fluorescent substance, such as quinine, in the case of the ultra-violet waves, or of a solution of iodine in disulphide of carbon, in conjunction with Prof. Langley's bolometer,† when the infra-red waves are experimented upon, might furnish important information on this point.

The experiments of Kerr on the effect of electrostatic force suggest that if light were reflected from a strongly electrified metallic conductor certain peculiarities would be observed. In the absence of experiments, which do not appear to have been made, it would be impossible to predict with certainty what these effects are likely to be; but it would seem probable that an electrified metallic reflector would behave like a doubly-refracting metallic medium having a *single* optic axis which is perpendicular to the reflecting surface. When light is reflected from the surface of a uniaxal crystal which is cut perpendicularly to the axis, the component vibration at right angles to the plane of incidence is reflected in the same manner as if the medium were isotropic. Under these circumstances we should anticipate that in the case of an electrified metallic reflector the component vibration *in* the plane of incidence would be much more strongly affected by electrification than the component at right angles to this plane. If this speculation should

* From *Nature*.

* The effect produced by a *single* reflection from magnetised glass would be too feeble to be detected; but Dr. Kerr suggested to me that an effect might possibly be observed by employing the method of multiple reflections.

† I do not know whether the bolometer is more sensitive to heat than a pair of average eyes are to light; if it is, experiments on the infra-red waves ought to be easier than experiments on luminous waves.

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be verified by experiment it would follow that the principal incidence and azimuth, and also the difference between the changes of phase of the two components, would be affected by electrification in a manner which could be observed.

In conclusion, I would point out that further experiments are required of the following nature :-

(1) Experiments on the reflection of light from magnetised *transparent* media, such as glass, perchloride of iron, and also, if possible, from liquid oxygen.

(2) Experiments on reflection from, and transmission through, magnetised metals, special attention being paid to the effects produced by the non-luminous portion of the spectrum.

(3) Experiments on reflection from *electrified* metallic reflectors.

LEGAL INTELLIGENCE.

John Hart v. The National Telephone Company.

On Friday last, in the County of London Sheriffs' Court, Holborn, before Mr. Under-Sheriff Burchell and a jury, the remitted case of John Hart *v.* the National Telephone Company came on for the assessment of damages. This was an action in which the plaintiff, a fruit and vegetable dealer, 13, Wardley-street, Garrett-lane, Wandsworth, sought to recover compensation from the defendant Company for personal injuries sustained through the falling of one of their wires.

Mr. Richard Harris, Q.C., with him Mr. J. W. Moyses, were for the plaintiff, and Mr. Compton Smith appeared for the defendants.

Mr. HARRIS said, in explaining the facts of the case, that the plaintiff was a man in a very substantial way of business. On June 17th he and his son were driving a cart laden with fruit from the market through York-road, Wandsworth. At the corner of a thoroughfare known as Jew's-walk some of the defendants' servants were engaged on the housetops repairing the wires, and suddenly one of the wires fell, catching the plaintiff around the neck and nearly strangling him. The cart was damaged, as was the contents, and the son was thrown into the road, sustaining severe injuries. It was fortunate that the plaintiff's presence of mind did not forsake him, otherwise his head would certainly have been severed by the very thin wire. Feeling that he was being strangled, he immediately dropped the reins and caught the wire, 80ft. of which had fallen, with his hands, and thus saved his life. At the time of the accident it was not thought that the injuries were of a very serious character; but the fact was that the larynx was nearly closed, and the medical men were unable to say whether it would not be permanent. That fact greatly inconvenienced plaintiff in his calling, and, in face of the seriousness of the case, he (Mr. Harris) appealed for heavy damages.

The PLAINTIFF, who was only able to articulate with difficulty, corroborated the opening statement, and, in answer to Mr. MOYSES, said that he bought largely in the London markets, and afterwards retailed the goods to small dealers, who hawked them in the streets on barrows. While he was driving along the York-road he suddenly saw something dazzling in front of him, and felt his neck clasped by a thin wire, similar to the piece produced.

Mr. SMITH severely cross-examined the plaintiff as to the injuries and his earnings.

After medical evidence had been given, Mr. SMITH contended that the plaintiff was in reality a costermonger. In that calling he had to use his voice very much, and by so doing the vocal cords had undoubtedly become thickened chronically. The wire was not blown down violently by a gust of wind, but quietly floated down. His contention was that the injuries were greatly exaggerated.

The jury assessed the damages at £195.

A second action was brought against the same Company by the son, but by consent it was arranged that judgment should be entered in his favour for £60, with costs.

Chelsea Electric Supply Corporation (Limited) v. London Electric Supply Corporation (Limited).

This case came before Mr. Justice Wright in the Vacation Court on Wednesday. Application was made *ex parte* on behalf of the plaintiff Company for an injuction extending over a week restraining the defendants from laying any distributing mains for supplying the electric light within the area supplied by the plaintiffs, except in accordance with the terms of an agreement entered into between the two Companies in July last. There had been correspondence between the parties, and the defendants having on Friday last justified what they were doing, this action was brought.

Mr. MORTON, Q.C., who made the application, on being called upon to explain the urgency of the matter, stated that the plaintiffs might be called upon to supply adjoining owners.

His LORDSHIP granted an injunction over next Wednesday, but intimated that in case the defendants felt that they would be injured by the order they could apply to him to-day in Chambers to dissolve the injunction.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 4, 1893.

The General Electric Company.—General Electric stock reached its lowest point on the Stock Exchange last week, having been sold for 31. Six months ago the stock was worth 117, and during the last two months has dropped about 50 points. The great depression in this stock follows partly from the general business depression in the United States, partly from being classed as an industrial stock—all of which class is now in considerable disfavour—and also on account of inflated capitalisation and the suspicion in regard to the real value of the many million dollars' worth of securities held as assets. At no time has it been thought by unprejudiced observers that the Company was in any serious danger, and that a more favourable view is now taken generally is shown by the continued rise in quotations during the present week. The stock is now selling for 47.

The Edison Lamp Patent.—Since the decision in favour of the Edison lamp patent at Milwaukee renewed interest has been manifested in regard to the date of the expiration of this patent. The opinion seems to prevail that it will expire with the Canadian patent on November 10, 1894. There are several questions, however, bearing on the date which may be carried to the Supreme Court. One of these is in regard to which date shall prevail in the English patent (there are three dates in this patent), another as to whether the law in regard to an American patent expiring with a foreign one previously granted applies to an American; and, finally, whether the date of application or issue of the patent shall hold. The first two issues are considered to have little or no weight. In regard to the third, the decisions of the lower courts have been uniformly against the Edison contention that the date of application instead of issue shall prevail, but as several questions have been overruled by the Supreme Court on interpretations of other points in the same statute, there is a probability that it may reverse the decisions of this question also.

Municipal Electric Lighting.—There seems to be a decided tendency at the present towards towns and cities undertaking the erection and operation of street electric lighting plants. This is particularly marked in the more intelligent districts of the United States and in some of the larger cities in the government of which Americans have yet a voice. In most of the large cities, however, there is little chance of municipal plants being erected, owing to the certainty that political corruption would result.

CORRESPONDENCE.

THE CITY AND SOUTH LONDON AND LIVERPOOL ELECTRIC RAILWAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I shall be glad if you will allow me to point out, with reference to the comparative figures given in your last issue, that the locomotive and generating expenses per train mile at Liverpool are less than the figure you quote, which is the price paid by the Liverpool Overhead Railway Company to the contractors, who, however, are running the line at an expense which shows a satisfactory margin on this figure, while the expenses in the case of the City and South London are, I believe, the actual expenses incurred in working.—Yours, &c.,

Wolverhampton, August 15, 1893. T. PARKER.

[We pointed out in the Note in question that the figure of 4d. per train mile for locomotive and generating expenses was the contract price.—ED. *E.*]

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TRADE NOTES AND NOTICES.

otices for insertion under the above heading must reach the Office ot later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

The 1893 Edition of "THE ELECTRICIAN" Electrical Trades' rectory and Handbook is NOW READY. This useful book contains r 1,000 pages, and several new and handy features have been led. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Com-rison with any similar electrical publication is specially invited.*

TENDERS INVITED.—The Gas and Lighting Committee of the lton Corporation invite tenders for the supply and fixing of ernating current transformers. Specifications and forms of nder may be obtained from Mr. J. H. Ryder, the borough elec-cal engineer; and tenders must be sent to Alderman Miles, airman of the above Committee, Gas Offices, Bolton, not later an September 16th. Some further particulars are given in our vertisement columns.

——— The Corporation of Aberystwith invite tenders for the ecution and maintenance of works for the supply of electricity thin the borough, in accordance with the terms of their Pro-sional Order. The conditions, plan, &c., may be inspected at the ices of Mr. A. J. Hughes, the town clerk, to whom tenders ust be sent in not later than September 8th. Some further par-ulars will be found in our advertisement columns.

——— The Dewsbury Board of Guardians invite tenders for hting the workhouse and premises by electricity, which are to in by the 31st inst.

——— The Electric Lighting Committee of Lancaster invite nders for the supply and erection of wrought-iron roofs over the gine and boiler house at their electricity works. Tenders must in by to-morrow (Saturday).

——— The municipal authorities at Dusseldorf invite tenders r the supply and erection of a complete electric lighting and wer plant, which must reach the Oberbürgmeister by 11 a.m. on ptember 1st.

——— The Municipality of Craiova (Roumania) invite tenders the lighting by electricity of a portion of the town. Specifica-ns, conditions, &c., may be obtained from the Secretary to the unicipality, and tenders must be sent in by 2 p.m. on September th (27th).

TENDERS ACCEPTED.—The tender of Callender's Bitumen, Tele-aph and Waterproof Company (Limited) has been accepted by e Richmond Town Council for the supply of the cables and wires the electric fire calls being installed in the borough. The estion of the tenders for instruments and apparatus has been left er for a time.

——— The City of Glasgow District Lunacy Board have cepted the tender of Messrs. Norman and Son, of Glasgow, r the installation of the electric light at their Gartloch Asylum, e amount being £5,628, and that of Messrs. Penman and Co., Glasgow, for three Lancashire steam boilers in connection with e above installation, for the sum of £1,874. 9s. 2d.

——— The Bolton Corporation have accepted the tender of e Brush Electrical Engineering Company (Limited) for the pply of dynamos and alternators for the central station, and that a local firm (Messrs. J. and E. Wood) for the engines. As men-oned in *The Electrician* a fortnight ago, Messrs. Hick, Har-eaves, and Co. have been successful in the tendering for the pply of boilers.

——— The Burton Town Council have accepted the tender of essrs. John Fowler and Company, Leeds (Limited) for the supply an overhead travelling crane for the electric light engine house, a cost of £337; and that of Messrs. Bryan Donkin and Co. fitting furnaces and boilers in connection with the new works, £285.

——— The tender of Messrs. Siemens Bros. and Co. (Limited) s been accepted by the Bradford Corporation for supplying and ing two Willans-Siemens combinations and two switchboards, amount being £3,025.

——— Mr. Thomas Rowbotham, of Coventry-road, Birming-m, is the successful tenderer for the construction of the central ctric light station at Worcester, the amount of his tender being 4,797.

——— The Municipality of Alcalá, Province of Madrid, Spain, rite tenders for the supply of the electric light to the district.

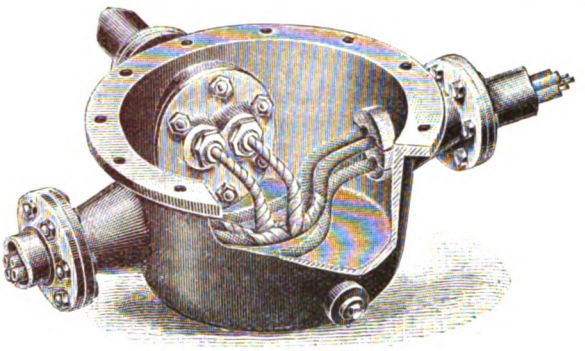
APPOINTMENT.—The Liverpool Watch Committee have appointed r. W. G. P. MacMuldrow electrical inspector for the city.

APPOINTMENT VACANT.—The Town Council of South Shields rite applications for the appointment of a resident electrical gineer to superintend the installation of the electric light in the Borough. Applications must reach Mr. J. Moore Hayton, town clerk, South Shields, not later than 12 noon on August 30th. Further particulars appear in our advertisement columns.

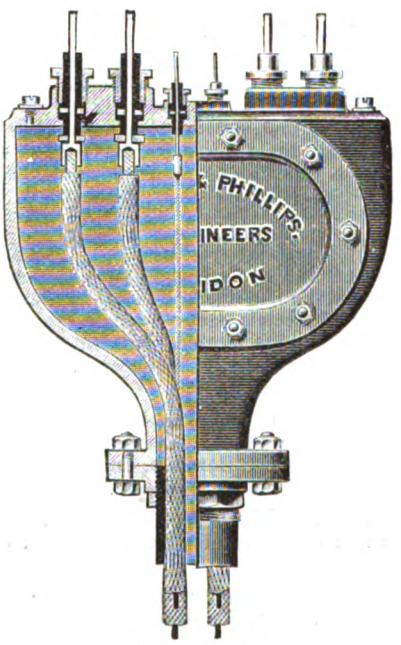
BANKRUPTCY.—Harry Austin and James Myers, trading as manufacturing electricians and electrical engineers at 7, Florence-terrace, Armley, near Leeds, under the style of Austin and Myers, have been adjudicated bankrupts. The first meeting of creditors will be held at the Official Receiver's, Leeds, on August 23rd, and the public examination will take place at the Leeds County Court on September 5th.

EMBEZZLEMENT.—Joseph Francis Chase, aged 50, was charged at the Guildhall on Friday with embezzling, on March 13th last, £2. 10s., received on account of his employers, Messrs. Alabaster, Gatehouse, and Co., Paternoster-row, London. He pleaded guilty, and was sent to prison for three months with hard labour.

MESSRS. JOHNSON AND PHILLIPS.—This firm have just issued some printed particulars with illustrations of their oil insulated underground electric light cables and mains, known as the Brooks system. This system is in use for public lighting at the Royal Observatory, Greenwich, at Brighton, Chatham, Keswick, Rochester, and Hong Kong, as well as being employed on a number of private installations in this country. The illustrations herewith



JUNCTION BOX.



TERMINAL BOX.

show the junction box and the terminal box used in the system, which is no longer in its experimental stage, as is shown by the fact that during the extremely bad weather of last winter the whole of the distribution mains at Chatham, Rochester, and Strood were successfully put down. Each section of the cables used, before being finally connected up, was severely tested with 5,000 volts alternating current, and although the circuit was frequently broken whilst the dynamo was run at this pressure, the mains did not afterwards show any weakness when tested with a sensitive reflecting galvanometer.

MESSRS. W. H. WILLCOX AND CO.—Messrs. Pontifex and Wood (Limited), of Shoe-lane, London, E.C., have transferred their "Farringdon" pump trade, and also the business connected with the "Penberthy" injector and ejector, to Messrs. Willcox and Co., who have purchased the stock of these goods, as well as a large

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stock of sight-feed lubricators, &c. Printed particulars of the "Penberthy" injector and "Farringdon" pumps can be obtained of Messrs. Willcox and Co., 34 and 36, Southwark-street, S.E., on application.

MECHANICAL STOKERS.—Mr. L. A. Edwards informs us that the Babcock and Wilcox boilers at the Bankside station of the City of London Electric Lighting Company are to be supplied with the patent circular furnace coking stokers, for which he is London agent.

BANDON.—A public meeting of the ratepayers having requested the Town Commissioners to refuse their consent to the granting of a Provisional Order to the Bandon Electric Light Company by the Board of Trade, the matter came before the Commissioners at their last meeting, but a final decision was postponed.

BARROW.—The Barrow Town Council decided, at a recent meeting, after a lengthy discussion, not to proceed with the application for a Provisional Order for the supply of electricity.

BRISTOL.—A dispute has arisen between the Corporation and the Poor-Law Guardians in respect of the assessment of the buildings, instruments, and apparatus used in connection with the electric light supply, which have been assessed at £3,000 gross and £2,000 net rateable value. Against this assessment the Corporation have appealed.

COATBRIDGE.—The Town Council have decided that their new municipal buildings shall be lighted by electricity.

COUNTRY HOUSE LIGHTING.—The contract for the lighting of Old Warden Park for Major Shuttleworth has been entrusted to Messrs. Drake and Gorham. The plant consists of two 10 H.P. fixed boilers to supply steam to two horizontal engines by Messrs. Clayton and Shuttleworth. The power will be available from either engine for driving a workshop. The number of lights is 350.

CHICHESTER.—At the last meeting of the Town Council it was resolved to instruct the Lighting Committee to ascertain whether the Gas Company would in future light the public lamps at a lower rate, having special reference to the lighting of the extended area of the city, and, further, to obtain information as to the cost of lighting the city by electricity, and to report to the Council on the matter generally at an early date.

DUNDALK.—The Electric Lighting Licence which was granted to the Town Commissioners in 1886 expired on July 1st. The Commissioners have made repeated applications for its renewal, which the Board of Trade at first refused to grant, suggesting that the Commissioners should obtain a Provisional Order. After considerable correspondence the Board of Trade have acceded to the application, and have renewed the licence for a further three years.

EDINBURGH.—At a meeting on Monday of the Edinburgh and Leith Corporations Gas Commissioners the question of the charge for supplying gas for the engines to be used by the City Council in the generation of the electric light was again under consideration, and, after some discussion, a motion that the Commissioners offer to supply the Corporation with gas on the same terms as were given to other large consumers was carried.

HARROGATE.—The Town Council at their last meeting commenced the consideration of the tenders which had been received for supplying electric light to the Borough, and, after some discussion, final decision in the matter was postponed.

JERUSALEM.—The Municipality of Jerusalem have under consideration plans and estimates for the installation of the electric light in the City.

KILLARNEY.—At the last meeting of the Town Commissioners it was decided to invite tenders for the public lighting of the town by electricity.

LINCOLN.—The Corporation have received a notice from the County of London and Brush Provincial Electric Lighting Company that it is intended to apply to the Board of Trade for a Provisional Order to authorise the supply of electricity within the city.

PAISLEY.—It being proposed to build a new hospital at Darnley, near Paisley, it has been decided that it shall be lighted by electricity, and Dr. J. T. Bottomley, of Glasgow, has been requested to report on the matter, and to submit a detailed specification, with estimate of cost.

STONEHOUSE.—The Local Board at their last meeting adopted a recommendation of the Town Hall Committee that the building be supplied with electric light at a cost not exceeding £500.

TAUNTON.—The Local Government Board have granted the Town Council a loan of £15,000 for the purpose of electric light works, repayment of principal and interest to extend over 25 years.

THE ELECTRIC LIGHT IN PAPER MILLS.—The works of the British Paper Company (Limited), Frogmore Mill, Two Waters (Herts.), have been recently fitted with the electric light. The work has been carried out by the London and Lancashire Electric and General Engineering Company (Limited), of Dalston. One of the features of the installation is the improved system of water-tight mains, joint boxes, and lamp fittings, which have been specially designed by Mr. C. N. Russell, the engineer and manager, with a view to resisting the effects of steam and moisture incidental to all paper mills. 16 c.p. incandescent lamps are used throughout the whole of the various departments, whilst a special arc lamp of 2,000 nominal c.p., intended for use in colour testing at night-time, is fixed in the beater house.

WHITEHAVEN.—The Harbour Trust have decided to light the harbour by electricity, and have agreed to an arrangement come to between the Harbour Committee and the Electric Lighting Committee.

WYNBERG (SOUTH AFRICA).—The central electric lighting station, which has been constructed by the Cape Town and Suburban Electric Lighting Syndicate (Limited), was opened on the 22nd ult. The installation consists of two Kapp dynamos by Messrs. Johnson and Phillips, working at a pressure of 130 volts each, and a storage battery plant consisting of 120 D.P. cells, which are capable of supplying 300 lamps for nine hours without the aid of the machinery. Ninety-nine 20-c.p. lamps and one 100-c.p. lamp take the place of the 60 oil lamps which were formerly used in the streets of Wynberg. The current is likewise supplied to business premises, places of worship, and residences.

YEADON.—The Local Board have had under consideration a scheme for an electric light installation, the cost of which is estimated at £3,500. The annual revenue is estimated at £750, and the working expenses at £540. It was resolved to apply to the Board of Trade for a licence empowering them to undertake the supply of electricity for lighting purposes.

PATENT RECORD

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

July 18, 1893.

13,888. C. WIESE. Canada. Improvements in electric current and current generator governors.

13,889. J. SHELL BOLTON and T. J. MURDAY. Newcastle-on-Tyne. An electrical self-winding clock.

13,900. R. G. BENNETT. London. Improvements in electric heating.

13,911. W. P. THOMPSON. Liverpool. An improved method of, and apparatus for, heating, welding, or working metals electrically. (Charles Lewis Coffin, United States.)*

July 19, 1893.

13,976. THE LONDON ELECTRIC WIRE COMPANY (LIMITED) and H. CAPEL. London. Improvements in dynamo brushes.

13,992. O. R. KNORR, C. SCHREIBER, and F. O. FISCHER. London. Electrical perforating or "pricking" device suitable for making tracings or stencils.

13,995. F. E ELMORE. London. Improvements in apparatus for the manufacture electrolytically of tubes and other articles of circular section.

13,996. F. B. BEHR. London. Improvements in vehicles and electric locomotives for single-line elevated railways.

14,000. S. Z. DE FERRANTI. London. Improvements in and relating to electricity meters.

14,003. A. A. GOLDSTON. London. Improvements in or connected with electric circuit-closing devices for series circuits.

14,012. H. BONNER. London. Improvements in electric batteries.

July 20, 1893.

14,030. B. THOMAS BOWDON. Improvements in apparatus for the suspension of electric light fittings.

14,056. W. H. LONGSDORF. London. Improvements in electrolytes for primary batteries.

14,076. H. H. LAKE. London. Improvements in electric measuring instruments. (A. H. Armen, United States.)*

14,087. H. H. LAKE. London. Improvements relating to incandescent lamps. (The General Electric Company, United States.)

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July 21, 1893.

14,091. F. W. T. Brain. London. Improvements relating to electric fuses.

14,105. A. Eckstein and H. J. Coates. Manchester. Illumination in connection with electric gas lighters.

14,130. J. Hargreaves and J. Bird. London. Improvements in the electrolysis of iodides, bromides, nitrates, and other salts.

14,131. J. Hargreaves and J. Bird. London. Improvements in the electrolysis of iodides, bromides, nitrates, and other salts, and in apparatus therefor.

14,155. F. J. Beaumont. London. Improvements in and connected with break feed appliances for electric arc lamps.

14,157. A. W. C. Cox. London. Improvements in electricity meters.

14,158. A. Browne. London. A new or improved electric lifeboat, messenger, and tender. (J. A. Cox and A. W. Read, India.)

July 22, 1893.

14,202. L. Pyke and E. S. Harris. London. Improvements in multipolar dynamo electric generators and motors.

14210. Siemens Bros. and Co. (Limited), and C. E. J. May. London. An improvement in tubular posts for telegraphic or other purposes.*

July 24, 1893.

14,233. T. J. Gough. Manchester. An improved method of transmitting electrical calls or signals.

14,271. C. Bertram and W. J. Hope-Johnstone. London. Improvements in the method of distributing electricity through substations, and in apparatus for that purpose.

14,258. F. J. Beaumont and F. Hallows. London. An improved electricity meter for registering the amount of current consumed on direct or alternating circuits.

14,259. W. Lowrie. London. Improvements in dynamo electric machines

July 25, 1893.

14,298. H. K. Tompkins. Gipsy Hill, Surrey. Improvements in the production of filaments for incandescent electric lamps.

14,315. C. W. A. Hertel. Manchester. Improvements in galvanic elements.

July 26, 1893.

14,422. J. B. Atherton. Liverpool. Improvements in apparatus for covering electric cables or conductors.

July 27, 1893.

14,469. A. W. Richardson. Manchester. Improvements in electric arc lamps.

14,472. J. Barkshire and E. Wright. London. A self-closing safety switch for use with shop door bell, circuits, &c.

14,474. Sir C. S. Forbes, Bart. London. Improvements in the arrangement of telephone circuits, and in apparatus therefor.

14,485. F. H. and H. Nalder, C. W. S. Crawley, and A. Soames. London. Improvements in multiple point switches suitable for use in electric lighting.*

14,486. S. Pitt. London. Improvements in electrically-working armoured turrets, guns, and other apparatus, and in apparatus suitable for these purposes (Messrs. Sautter, Harlé, and Cie, France).*

14,489. R. Chararria-Contardo. London. Improvements in or connected with turnstiles and electric counters connected therewith.*

14,492. G. G. M. Hardingham. Improvements in or in connection with electric conductors. (The firm of Felten and Guilleaume, Germany.)

14,498. J. B. Furneaux and G. W. Money. London. Improvements in dynamo-electric generators and motors.

July 28, 1893.

14,505. L. Voltmer. London. A process and apparatus for obtaining pure metallic manganese by electrolysis.

14,516. A. F. W. Kreinsen. Manchester. Improvements in and connected with electric furnaces.*

14,525. H. C. Harold. London. An improvement in relation to the covers for casings carrying electric light conductors.

14,533. Siemens Bros. and Co. (Limited). London. Improvements in supplying electrical energy to motor vehicles on electric railways, and to electromotors on vessels, by means of alternative-current transformers. (Messrs. Siemens and Halske, Germany.)

14,534. H. C. F. Störmer. London. A cathode for electrolysis.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

13,395. Mercier. Electrical signalling.

13,543. Siemens Bros. and Co. (Limited), (Siemens and Halske). Electrical installations.

16,056. Castner. Electrolytic decomposition of alkaline salts.

16,489. Taylor. Electrical rock drill.

17,691. Havaux. Cutting glass by electricity.

1893.

10,347. Spangenberg. Battery switches.

11,143. Dorman and Smith. Electrical switches, &c.

11,622. Sanders and Thompson. Magnetic separation.

COMPANIES' MEETINGS AND REPORTS.

Cuba Submarine Telegraph Company (Limited).

The forty-fourth ordinary general meeting of this Company was held at the offices, 58, Old Broad-street, on Wednesday last. The chair was taken by Mr. Thomas Greenwood.

The SECRETARY (Mr. James Scott) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, I apprehend that you have already made yourselves acquainted with the contents of the report and accounts, which although nominally presented to day, have been in your hands for a week, so it will therefore be unnecessary to read them again. Indeed, I should not be at all surprised, seeing that our accounts are so similar from half-year to half-year if you almost knew them from memory. There are, however, one or two salient points which I should like to bring to your notice. The first is that there has been an improvement in the total receipts of upwards of £600, comparing those of the past half-year with those of the corresponding period of the previous year; and the working expenses have been less, taking the same periods for comparison, by £562. We therefore have an improvement of £1,164, which goes to swell the balance carried forward to next half-year, which is about £1,167 more than we carried forward 12 months ago. The reserve which has been made this half-year has been precisely similar in amount to that which we made 12 months ago, but we have divided it this time, carrying £1,500 to a reserve against any loss that may arise from the failure of banks, and £5,500 to the general reserve fund, whereas in the former period we carried the whole £7,000 to the credit of the reserve fund only. I do not think we shall make a great loss by the banks, but it is always well to err on the safe side, and it is well also to strike the iron while it is hot, and to make hay while the sun shines. Our half-year is sufficiently good to make the reserve, and, therefore, to be quite sure that we have an ample reserve for such a purpose, we have carried that £1,500 to the credit of that account. You are aware that a considerable number of banks, especially the Australian ones, have gone into liquidation, and that as we divided our deposits over a large number of banks we necessarily have a considerable number of them upon our list of defaulters, although the amounts deposited with each are comparatively small. Those in the list abstract C have been reconstructed, our deposits with them amounting in all to £24,000, and I have no reason to doubt that, with the time afforded to these banks, when these deposit notes fall due, a great majority of them, at any rate, will be honoured at the dates fixed. There is, however, one item—I was going to say in the accounts, but it is not in the accounts, and is conspicuous by its absence—that is, the charge for the annual payment for the purchase of the cable which was laid in 1881 between Cienfuegos and Santiago. That payment has been completed, and we have no further charge to make in our accounts. I do notthink there is any other thing that calls for notice, but if shareholders desire any further information we are at their disposal. The resolution that I have to propose is as follows:—

"*That the report and accounts for the half-year ended June 30th last, now submitted, be received and adopted.*"

Mr. CHARLES W. PARISH seconded the motion.

The Rev. JOHN WILLIAM BROWN: Mr. Chairman and gentlemen, we are a very small number here to-day, so far as shareholders are concerned, and I take it, Mr. Chairman, that that is a compliment to yourself and your co-Directors, signifying the complete trust which we as shareholders have in our Board. I should have liked to see more shareholders present, but I suppose the excessive heat of the weather has rather frightened them. However, as there are one or two items of special interest in the accounts laid before us, I made up my mind to brave the heat and to attend the meeting. I am very glad to hear our good Chairman assure us that due provision has been made in the accounts for any loss the Company may suffer owing to the unfortunate liquidation of the Australian banks. I must say that at the time when the news came concerning the financial storm in Australia, when I knew that some of our banks were affected, it filled me with considerable alarm; but I felt the utmost confidence that our Board would do their very best to steer this ship through the storm, and I believe that they have done so in the way which has just been explained to us, by putting £1,500 to reserve to meet any contingent losses. Our Chairman mentioned the sum of £24,000, but I could not quite catch the meaning of his remark. To what did that £24,000 refer? What are the banks alluded to? Did the Chairman mean to say that that £24,000 was rather doubtful? I should like a little further light thrown on that point. Then, with respect to the reserve fund, it has now reached £100,000, and I have always been given to understand that when the reserve fund reached that amount no further sum would be taken from revenue account year by year to increase it. I should like our Chairman to give us a word or two as to what is in his mind and in the minds of his colleagues as to what is going to be done with the reserve fund. In what way will the shareholders benefit by the fact that the sum has reached £100,000, and that it is not proposed to increase the amount? Then, will the Chairman enlighten us by giving us any further information, if he has any, about the lawsuit?

Mr. W. GRIFFITH: Looking over the report and balance-sheet I came to somewhat the same conclusions as the previous speaker, but it struck me rather forcibly that it would be much more pleasant, instead of increasing our reserve fund, to divide it among the shareholders, the more especially as our reserve fund is not altogether in a satisfactory state. We find that we have put our money into bags with holes in them—that these Australian banks are willing enough to receive our money, but unfortunately, they do not keep it safely. I am afraid, looking at the form of the accounts, that we are to take the £1,500 put to reserve on account

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of the banks as a real loss. You add up the items of the investments and then deduct the £1,500 as if we really could not count upon the whole sum, except minus this £1,500. It was wise and prudent to put that amount aside, because no balance-sheet is worth anything unless it puts a proper value on doubtful debts and bad investments. There was one point, however, which struck me, on which, perhaps, you would give us some information, although you may have done so already, as I regret that I was a little late in arriving at the meeting. I mean with respect to the intention of the board to lower the rates for messages. If there is competition that may be absolutely necessary, but in a small company like ours I think it is wisdom to make as much as we can out of our plant. In a large company like the Anglo-American, where the business comes in in large volumes, it may be wise to charge small rates, but in a Company like ours—certainly a most successful one—we have not these large amounts, and it seems to me that the way is to make as much as we can out of our plant. At the same time, I admit that you have superior information, and there may be competition which we must meet by lowering our rates. I would also reiterate one of the remarks of the last speaker, and ask you if you will kindly inform us what is to be the ultimate fate of our reserve fund. It is a most beneficial thing that it may be used to equalise dividends. That is always in favour of putting a large sum thereto, but it creates a little doubt in our minds. You talk of equalising the dividend in the future, as if you anticipated a stormy and unpleasant period of business in the next 12 months. I hope, however, that you will be able to reassure us, and tell us that we have not much to fear, and that we may hope that our business will keep up, and that we shall receive the same large and pleasant dividend as regularly and as punctually as before.

The CHAIRMAN: Does any other shareholder wish to put any questions? If not, I will answer these. Replying to Mr. Brown, as to which banks are included in the £24,000, please take abstract C in your hands, and include the whole of the banks there with the exception of the Colonial Bank of New Zealand, £1,000, which falls due in November next, and which we shall doubtless receive. Without enumerating them you will find them all in abstract C. All the banks there mentioned, with the exception of the Colonial Bank of New Zealand, have been or are in liquidation, and we shall have to wait for our money for several years. Meantime, however, we shall—and we have up to the present time—received our interest, and I see no reason for that being reduced or not paid. The Australians have gone through very trying times, but I think that the form in which the present companies are arranged will give them such a strong position that they will be in a more flourishing condition after their reconstruction than they were before. They were liable for large amounts of money before, payable at different dates, and early dates, too. Now, by the re-arrangement, all these payments are postponed, and the banks stand practically in the position of new institutions with fresh capital to go on with their business. I have very great faith in Australia, and in the five years' time that has been given I have great hope that we shall receive our money; but, as I explained before Mr. Griffith arrived, we thought it would be better to err on the safe side, and as we had a considerable sum of money this half-year, we thought it was wise to make this provision, which we can afford to do. As regards the reserve fund, you must remember that our cables are not new. One of them was laid in 1870, and is therefore 23 years old. That is the line between Cienfuegos and Batabano. The other part of that line, laid at the same time, between Cienfuegos and Santiago, has been long since abandoned. In 1875 another cable was laid between Santiago and Cienfuegos, which, therefore, is 18 years old. Another was laid in 1881 between the same two points, and is therefore 12 years old. We have one cable almost new, between Cienfuegos and Batabano, it being only two years old. Regarding the 23 years' old cable, it is not improbable that we shall have to replace it, which may make a considerable dip into our reserve fund. I quite agree with the proprietors who have spoken on the subject that a reserve fund of £100,000 is large, but I do not think it is too large, having regard to the facts which I have mentioned, of the age of our cables, and to the fact that we may have to come into competition, and to reduce our rates. As regards the reduction of rates, it is not the intention of the Directors to make any reduction until it is necessary, nor until we see that it is entirely to benefit us. We must look ahead, and I can only say that negotiations are pending with a view to a reduction of rates. Although these arrangements are not completed we thought it only right to let the shareholders know that they were in contemplation, but we shall not make any reduction until it is necessary to do so. I think I have said as much as I ought to say in a meeting of this kind, because, as you know, our report is printed and circulated, and our foes can read it as well as our friends. The lawsuit has been pressed and will be pressed; and I think it is time now to get it carried through as quickly as possible. We are doing all we can to get a decision, and we have very great hope that it must necessarily be in our favour. I think I have answered all the questions. If not kindly remind me of any I have omitted.

The resolution, that the report and accounts be adopted, was carried unanimously.

Mr. George Keith was re-elected a Director, and Mr. John Gane an auditor, and a vote of thanks to the Chairman having been passed, the proceedings terminated.

International Electric Subway Company (Limited).

On Thursday, last week, the first ordinary general meeting of this Company was held at 72, Bishopsgate-street Within, E.C. Mr. John L. Martin in the chair. The following note of the proceedings has been forwarded to us:—

The SECRETARY having read the notice convening the meeting, the CHAIRMAN said that "since the statutory meeting held last year two contracts for supplying the Johnstone system of conduits have been carried out; one for the City of London Electric Lighting Company, who laid about a quarter of a mile of the conduit in Blackfriars. The types used were the nine-way and the six-way, each duct or way measuring 2½ in. square. It will be readily understood that as this was the first time the conduct had been laid in England it was a most important moment for this Company; it is therefore a matter for congratulation that the work done was perfectly satisfactory, the top and bottom troughs exactly fitting together, and when the conduit was keyed up it made a solid structure. It may be mentioned that no skilled labour is required, and no special tools for laying the conduit. In fact, a great deal of the work can be done by boys; in this way the cost of laying is much less than where separate pipes are used; each pipe would cost 6d. per yard run to lay and joint, whereas 9d. per yard run covers the cost of laying and jointing the nine-way conduit. Some of the conduit has also been supplied to the Keswick Electric Lighting Company (Limited), and their engineer was so much pleased with it that during the last few days he has ordered more with handholes for making house connections. During the last month we have obtained the contract for all the underground mains at Portsmouth. The types used will be a three-way and a two-way; each duct will measure 2½in. square, and the house connections will be made by means of the handholes, which are a special feature of the system. The amount of the contract is £12,000, exclusive of accessories. The work will be commenced in about a fortnight's time. It is most important that the conduit is to be laid in a well-known town like Portsmouth, for there its many advantages will be seen and understood in a way which is impossible where only a short piece of conduit is laid. The Company still owns the patents for France, Austria, Belgium, and Italy, as it has not been thought advisable to dispose of these until a large contract had been obtained in England. Negotiations are now being entered into for working some of the foreign patents on a Royalty." The Chairman concluded by moving the adoption of the report and statement of accounts.

The motion was seconded and carried unanimously.

A cordial vote of thanks was then passed to the Directors, and to the Managing Director (Mr. Margesson) for the zeal he had shown in promoting the interests of the Company, after which the proceedings terminated.

Oriental Telephone and Electric Company (Limited).

The following report of the Directors for the year ended December 31, 1892, will be presented at the thirteenth ordinary general meeting of the Company, to be held at the Cannon-street Hotel, London, on Wednesday, August 23rd, at 1 p.m.:—

As mentioned to the shareholders at the last annual general meeting, an appeal was lodged by Mr. Ness against the decision of Mr. Justice Kekewich in the matter of the declaration and distribution of the previous dividend. The Court of Appeal having reversed the judgment of Mr. Justice Kekewich, the Directors had no alternative but to submit the case to the House of Lords for a final interpretation of the Agreement with the vendors. The annual meeting has consequently been delayed pending the result of this appeal. Judgment was given by the House of Lords on the 27th ult., which allowed the appeal and upheld the decision of Mr. Justice Kekewich. The dividends, therefore, falling to the Vendor shareholders, have to be paid over to the Ordinary shareholders until such time as the arrears of interest due to the latter for the first five years after the incorporation of the Company have been satisfied. These arrears, after payment of the last dividend, amounted to about £13,000.

The revenue account for the year shows a balance to credit of £9,035 5s. 11d., which has been transferred to Profit and Loss, and including £1,957. 16s. 4d. brought forward from 1891, there remains a balance for disposal of £11,043. 2s. 3d. The Directors propose to deal with this as follows:—To write off £251. 13s. 6d. for legal expenses, £77. 10s. 4d. being 50 per cent. of the Company's claim on the liquidators of the New Oriental Bank Corporation in respect of a balance at Mauritius; £533. 15s. 4d. in reduction of capital expenditure; to transfer £2,500 to reserve; and to pay a dividend at the rate of 2½ per cent. on the total paid-up capital of the Company, free of income-tax, carrying forward £3.191. 10s. 10d. This dividend, together with that declared on the Vendors' shares and applied to the Ordinary shares, amounts to £3. 12s. 2d. per cent. on all Ordinary shares issued prior to February 4, 1886.

Although the balance of revenue account shows but a small improvement over the previous year, there has been a considerable extension of business at every agency, including those of the subsidiary companies. The remittances and dividends, however, received from the East are, with the exception of Egypt, the equivalent of a silver currency, and, but for the further decline in the value of that metal during the year, the revenue account would have shown a more favourable result. The Bengal Company has paid a dividend of 6 per cent., and the Bombay Company one of 4 per cent. for the past year, the last-named company again applying Rs.10,000 to reserve and depreciation instead of increasing its dividend. Notwithstanding that the Directors of the Telephone Company of Egypt report that one of the late officials of that Company had been guilty of grave irregularities, they have been able, after payment of debenture interest, to distribute the usual dividend of 6 per cent. on the Preferred shares, to write off £426. 7s. 4d. for depreciation, and to carry forward £1,446. 7s. The China and Japan Telephone Company closed its accounts for the past year with a surplus on revenue account of £549. 15s. 7d., after payment of debenture interest; the Directors of that Company, however, in view of currency contingencies, did not recommend a dividend, but applied the amount in part towards the reduction of capital expenditure and depreciation of stores, carrying forward the balance.

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The court has finally approved the amendment of the Company's memorandum of association as sanctioned by the shareholders, and the name of the Company is now registered as The Oriental Telephone and Electric Company (Limited).

The Directors to retire at the present meeting are Messrs. G. B. Frost and B. St. John Ackers, both of whom, being eligible, offer themselves for re-election. The Auditors, Messrs. Deloitte, Dever, Griffiths, and Co. also offer themselves for re-election.

Brush Electrical Engineering Company (Limited).

The following is the Directors' report, to be presented to the shareholders at the general meeting to be held at Cannon-street Hotel, London, E.C., on Thursday next, August 24th, at 3 p.m. :—

The profit and loss account for the year ended June 30, 1893, shows a gross profit of £50,158. 6s., including the amount brought forward from last account, to which must be added £3,150. 12s. 2d., the balance of premium after payment of expenses arising from the additional Preference and Ordinary shares issued during the year. After deducting standing charges, maintenance of buildings, plant and patents, interest on debenture stock, and the whole cost of concentrating the Company's works at Loughborough, amounting to £1,328. 11s. 2d., there remains a balance of £26,394. 12s. 9d to be dealt with. After providing the full dividend on the Six per Cent. Preference shares for the year, and an interim dividend at the rate of 5 per cent. per annum, which has already been paid on the Ordinary shares for the half-year ended December 31, 1892, the Directors recommend that the whole amount standing to the debit of preliminary expenses account, amounting to £1,575. 2s. 3d., be written off; and that a further dividend at the rate of 7 per cent. per annum be paid on the Ordinary shares for the six months ended June 30, 1893, leaving £815. 5s. 3d. to be carried forward.

The capital account has been increased during the year by the issue of 15,000 Six per Cent. Preference shares, and 11,617 Ordinary shares, which have been fully subscribed. During the year the sum of £10,681. 19s. 10d. has been expended on capital account, chiefly in additional plant and buildings at Loughborough, and further extensions of the Company's works there are still in progress. These extensions have been rendered necessary by the increasing volume of central station plant which the Company are being called upon to manufacture.

Good progress has been made with the construction of heavy plant for the Bankside station of the City of London Electric Lighting Company, the dynamos for which are each capable of supplying current for 15,000 glow lamps of 8 c.p. The first two of these are now delivered, and four more are in course of construction at Loughborough.

During the past year the Directors have concluded a satisfactory arrangement with the Otis Elevator Company, of Mansion House-buildings, E.C., for the manufacture at the Loughborough works of the elevators and other appliances required by them. In view of the growing demand for electrically worked lifts, arising from the introduction of electric supply into the leading towns of Great Britain and elsewhere, it is thought that the step which has been taken will prove of increasing advantage to your Company in the future.

The home business of the Company generally continues in a healthy state; and the expiry of the Edison master glow lamp patent next November will probably give an additional impetus to central station development. Your Directors have made arrangements to resume the sale of glow lamps of their own manufacture as soon as the above Edison patent expires.

The Australian branch of your business has naturally received a severe check owing to the late financial crisis in the Colonies, but your Company has sustained no loss through any of the bank failures which have taken place. In Austria your business shows a steady growth, and the factory is kept fully employed on Continental orders. During the year the Municipality of Temesvar has purchased your central station there. The amount thus received has been deducted from the property accounts of your foreign and Colonial branches, a separate balance-sheet of which is subjoined as usual.

The outlook for the current year is good. Your works are at present fully employed, and fresh orders are coming in well; whilst in the coming year the full benefit of the economies anticipated from the concentration of the Company's manufacturing operations at Loughborough should now be felt. It is believed that these economies will prove sufficient to provide the dividend upon the last issue of shares.

The Directors deeply regret to record the loss by death of the late Chairman, the Duke of Marlborough. The active interest he displayed in all questions affecting the electrical industry causes his loss to your Company to be the more keenly felt. Mr. J. B. Braithwaite has been elected Chairman in his place. Mr. E. Garcke has resigned his position on the Board, and, subject to the confirmation of the shareholders at the general meeting, Mr. Arthur Ayres has been elected to succeed him. Messrs. J. B. Braithwaite and B. H. Van Tromp retire by rotation, and, being eligible, offer themselves for re-election. The auditors, Messrs. Cooper Brothers and Co., also retire and offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

G. E. BELLISS AND CO. (LIMITED).—This Company was registered on August 11th with a capital of £150,000 in £10 shares (of which 10,000 are Ordinary and the remainder 6 per cent. Cumulative Preference), to execute and carry into effect an agreement between George E. Belliss and Alfred Morcom, of the one part, and the Company, of the other part, for the sale to and purchase by the Company of the business of engineers and boiler makers carried on by the said Messrs. Belliss and Morcom under the trade name of "G. E. Belliss and Co.," at the Ledsam-street Works, Birmingham, and to carry on the said business, and also that of electricians, electrical, mechanical, and general engineers, engine manufacturers, suppliers of electricity for the purposes of light, heat, motive-power, or otherwise, and manufacturers of and dealers in all machinery, apparatus and things required for, or capable of, being used in connection with the generation, distribution, supply, accumulation, and employment of electricity. The subscribers (with one share each), are :—G. E. Belliss, Mrs. G. E. Belliss, and Miss T. E. Belliss, "The Dell," King's Norton; A. Morcom and Mrs. A. Morcom, "Trelawne," Augustus-road, Edgbaston; Thomas Simpson, 6, Waterloo-street, Birmingham; G. B. Parrott and T. H. Parrott, 21, Duchess-road, Edgbaston; and J. Belliss, 64, Francis-road, Edgbaston. The first Directors are: George E. Belliss, Alfred Morcom, and Albert E. Seaton.

GARDINER, SONS, AND CO. (LIMITED).—The Company was registered on August 10th with a capital of £80,000 in £10 shares, to carry on as a limited Company the business of ironmongers, iron merchants, mechanical, electrical, and general engineers, machinists, iron and brass founders, &c., carried on by John Gardiner and Thomas C. Gardiner, under the trade name of "Gardiner, Sons, and Co."

NEW BRITISH ELECTRIC INSTALLATION CONTRACTORS (LIMITED). This Company, which is a reconstruction of the British Electric Installation Contractors (Limited), of Worcester, has entered into an agreement with the latter, by which the old Company has sold it business for £3,000, payable in £6 per cent. Mortgage Debentures of the new Company, redeemable in seven years from March 5, 1893, the purchase taking effect as from February 1st.

NORWICH ELECTRICITY COMPANY (LIMITED).—The annual return for 1892, made up to December 31st, was not filed till July 8, 1893. The nominal capital is £50,000, in £10 shares, of which 1,774 have been taken up. £8 per share has been called, resulting in the payment of £14,226. 10s. (which includes amount paid in full on 36 shares), leaving £37. 10s. in arrears. The usual return for 1893, made up to July 1st, was filed on the same day as the foregoing, when the full amount had been called on each share taken up, £16,382. 10s. being paid, leaving £857. 10s. as yet unpaid.

PACIFIC TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 24th, has been filed. 18 shares, out of a nominal capital of £2,000,000, in £10 shares, have been taken up, and the full amount has been called, resulting in the payment of £130, leaving £50 in arrears. It is stated that no business is being done by the Company. The shareholders include the Countess of Milltown, Sir J. P. Corry, Bart., M.P., Sir Daniel Cooper, Bart., the Earl of Radnor, J. Henniker Heaton, M.P., Sir W. J. Clarke, Bart., Sir S. Wilson, M.P., Sir Donald Smith, K.C.M.G., Sir Sandford Fleming, C.M.G., and others.

RIVER PLATE ELECTRICITY COMPANY (LIMITED).—The annual return of this Company, made up to May 22nd, was recently filed. The nominal capital is £500,000, divided into 49,900 Ordinary shares of £10 each, and 1,000 Founders' shares of £1 each, of which 13,557 Ordinary and 892 Founders' shares have been taken up. 2,400 of the former have been issued as fully paid, while the full amounts have been called on the remainder. The calls paid amount to £110,892, while a sum of £1,570 is unpaid.

SCOTTISH HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED).—The annual return of this Company, made up to June 30, 1892, was filed on July 17, 1893. As no meeting has been held and no business carried on, only the seven signatories' shares out of a nominal capital have been taken up and no calls made.

SHEFFIELD ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The first annual return of this Company, made up to and filed on July 27, 1893, shows that out of a nominal capital of £98,000, divided in 14,000 shares of £7 each, 4,000 shares have been taken up, which were issued with £5 considered as paid on each. A call of £1 per share has been made, which, with the exception of £5, has been paid.

SIEMENS BROTHERS AND CO. (LIMITED).—The annual return of this Company, made up to July 11th, has been filed. The whole capital of £500,000, in shares of £100 each, had been taken up, and a call of £85 per share made, and £425,000 paid in respect thereof.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended August 13th were £825, as against £721 for the corresponding period of last year, being a increase of £105. The total receipts for the half-year amount to £5,051, against £4,661 in the corresponding period of 1892, being an increase of £390.

DIRECT SPANISH TELEGRAPH COMPANY.—This Company, notifying the interruption of the Falmouth-Bilbao Cable, announce that arrangements have been made by which telegrams for Bilbao, Madrid, and other places in Spain can, during the interruption be promptly forwarded by the Eastern Telegraph Company's route. Telegrams will be received at the Direct Spanish Company's stations, 74, Gracechurch-street, and 280, Winchester House, E.C., and at the Eastern Telegraph Company's stations in London, Liverpool, Manchester, and Glasgow.

KNIGHT AND CROWTHER (LIMITED).—At the second annual meeting of this Company held last week dividends of 6½ per cent. on the Preference shares and 5 per cent. on the Ordinary shares were declared.

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STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to appoint a settling day in and to grant a quotation to a further issue of £50,000 Five per Cent. Debentures, Nos. 5,001 to 10,000, of the Metropolitan Electric Supply Company (Limited).

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended August 11, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,354.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Aug. 9.	Price Wednesday, Aug. 16.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 16. Highest	Lowest.
			TELEGRAPHS			£ s. d.			
£1,134,640	Stock	12/6	Anglo-American	49 50	49 50	5 10 0	Jan. Apr., July, Oct	..	..
£2,932,680	Stock	25/0	Do. Preferred	92 93	91½ 92½	5 18 11	" "	93	92
£2,932,680	Stock	5/0	Do. Deferred	9½ 10	9 9½	..	.. ..	9⅝	9
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	99 102	99 102	3 18 5	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11⅞ 12½	11⅞ 12½	5 6 1	Mar., June, Oct., Dec	..	..
£36,400	£100	5%	Do. 5 per Cent. Bonds	99 103	99 103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1900)	107 111	107 111	4 10 1	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	120 130	120 130	5 7 8	April and October	..	..
16,000	10	8/0	Cuba Submarine	11½ 12½	11½ 12½	6 8 0	February and August	12¼	..
6,000	10	10%	Do. Preference 10 per Cent.	18½ 19½	18½ 19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½ 3½	2½ 3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9 10	8½ 9½	5 5 3	" "	8⅝	..
60,710	20	3/6	Direct United States xd	11⅜ 12	11½ 11⅝	5 19 2	Jan., Apr., July, Oct	11⅝	11½
400,000	10	5/6	Eastern	14⅝ 15	14⅜ 15	4 6 8	" "	15	14⅞
70,000	10	6%	Do. 6 per Cent. Preference	16¼ 16¾	16¼ 16¾	3 11 8	" "	16⅛	16⅛
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112 115	112 115	3 9 7	May and November	114½	112½
£105,900	100	5%	Do. 5 per Cent. Debenturer, 1899	106 109	106 109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15½ 15⅝	15 15½	4 11 10	Jan., Apr., July, Oct.	15⅞	15⅞
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	111 114	110 113	3 10 10	February & August	..	..
£70 600	100	5%	Do. 5 p. c.(Austln. Gov. Sub.) Debs 1900	102 105	102 105	4 15 3	January and July	102¾	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb.,1900	101 104	101 104	4 16 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101 104	101 104	3 16 11	February & August	..	..
£200,000	£25	..	Do. 4% Mauritius Sub. Debs.	103½ 103¾	.. ..	..	May and November	..	..
180,227	10	4/0	Globe Telegraph and Trust	9⅝ 9¾	9⅝ 9¾	4 13 8	Jan., Apr., July, Oct.	9¾	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	15½ 15⅝	14½ 15½	3 19 4	" "	15⅝	15
150,000	10	30/0	Great Northern	19½ 20	19½ 20	4 5 0	Jan., April, and July	..	..
£100,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105 108	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	39 42	39 42	5 19 1	May and November	40½	39½
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	3 6 8	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs.	100 103	100 103	3 17 8	.. ..	..	..
11,802	8	4/0	Reuter's	4½ 5½	4½ 5½	..	April and October	..	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6 per Cent.	115 120	115 120	5 0 0	" "	116	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July	..	..
£260,900	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	2½ 3½	2¼ 3½	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	97 101	97 101	7 18 5	June and December	..	..
88,321	10	6d.	West India and Panama	1 1½	1 1½	..	..	1⅛	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 10¾	10½ 10¾	5 11 7	May and November	10½	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	105 108	105 108	4 12 7	June and December	..	..
64,242	15	4/6	Western and Brazilian	6¾ 7½	6¼ 6¾	5 15 7	May and November	6⅞	6⅝
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5⅞ 6½	5⅞ 6½	..	..	6	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1½ 1⅝	1½ 1⅝	..	..	1½	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	104	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs.,Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120 125	120 125	5 12 0	May and November	..	..
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	101 104	101 104	5 15 5	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	2 3	2 3	..	..	..	..
224,880	14/0	3½d.	Consolidated Telephone Const. & Maintenance*	½ ½	1⅛ 1⅜	..	May and November	..	..
220,000	£1	4½d.	Oriental (11s. paid)	⅜ ½	1⅛ 1⅛	7 18 2	Yearly	..	..
458,867	5	2/6	National	4½ 4¾	4⅜ 4⅝	5 8 1	June and December	4⅝	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14½ 15½	14½ 15½	3 17 5	" "	15⅜	15½
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14 14½	14 14½	4 2 9	" "	14⅜	14½
90,950	5	2/0	Do. 5% Non-Cumulative 3rd Pref.	5½ 5⅝	5½ 5½	4 10 11	.. ..	5⅜	5⅛
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	110 113	111 113	3 19 8	January and July	111⅜	111
58,000	5	1/0	United River Plate	2 2½	2 2¼	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	10¾ 11½	10¾ 11½	..	..	..	..
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½ 13	12½ 12¾	..	..	12⅝	12½
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	..	5 5½	..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	.. ..	..	..	..	..
8,322	£5	..	House to House Electric	..	1¾ 2¾	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..	5⅜ 5⅝	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	6 6½	..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4⅞ 4⅞	4⅞ 4⅞	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6½ 6¾	6½ 6¾	..	..	..	..
111,000	5	..	London Electric Supply	¾ 1	.. ..	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	5¾ 6¼	5¾ 6¼	3 4 0	..	..	..
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102 105	102 105	4 15 3	June and December	..	..
6,452	£10	..	Notting Hill Electric	5 6	5 6	..	..	..	..
19,980	£5	9½%	St. James' and Pall Mall	6½ 6¾	6½ 6¾	..	..	6⅞	..
20,000	£5	7%	Do. 7 per Cent. Preference	7¾ 8¼	7¾ 8¼	4 4 10	..	8⅛	..
59,900	5	1/6	Westminster Electric Supply (fully paid)	5 5½	5 5¼	3 3 8	..	5⅝	5½
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/6	Brush Electrical Engineering	3½ 3¾	3½ 3¾	..	..	3⅝	3⅜
75,000	2	6%	Do. 6 per Cent. Preference	2⅞ 2⅞	2⅞ 2⅞	5 1 1	..	2⅞	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107 109	107 109	4 2 7	March & September	108½	107½
20,000	5	3/6	Crompton and Co., 7 per Cent. Cumulative Pref xd	4¾ 5¼	4¾ 5¼	6 1 9	January and July	..	..
12,139	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	1¾ 2¼	..	..	..	..
49,900	10	12/0	Electric Construction	1½ 2	1½ 2	..	..	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	¼ ½	¼ ½	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22	21½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	1½ 2½	1½ 2½	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	4/0 5/0	4/0 5/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	2 2½	2 2½	14 11 6	May and November	2⅝	..
37,350	12	12/0	Telegraph Construction and Maintenance xd	33 35	33 35	5 2 10	March and July	34½	33½
£150,000	100	5%	Do. 5 per Cent. Bonds, red.1894	101 104	101 104	4 16 2	January and July	101	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	4%	City and South London Railway xd	35 37	35 37	1 13 9	May and November	..	..
37,500	£10	£10	Liverpool Overhead Railway	4½ 4¾	4¾ 5	..	..	..	..

* 2s. returned of capital.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 797.—Vol. XXXI. FRIDAY, AUGUST 25, 1893. PRICE FOURPENCE. *Annual Subscription (U.K.), 19/6*

NOTES.

A Paper was read on Tuesday last by Prof. S. P. Thompson before the Electrical Congress at Chicago, on "Ocean Telephony." Mr. Oliver Heaviside has written on this matter on more than one occasion, and by a coincidence, deals with it in our present issue. Prof. Perry recently contributed a rather abstruse Paper to the Physical Society on it, and on January 6th we called attention to the subject and gave an abstract of Prof. S. P. Thompson's first patent. Mr. Preece also has turned his attention to this problem but on different lines. The present Paper, the first half of which will be found in another column, gives the theory in very simple language, and contains a number of suggestions for putting the method into practice. Neither practical directions for the design and construction of cables for submarine telephony are given, nor does the author concern himself at present with practical considerations affecting the volume of traffic, the hours of working, and other commercial considerations. Whether such a cable if ever laid across the Atlantic would be more useful for telephony or, for high-speed working at 400 words or so per minute, need not here be discussed. It must, of course, be remembered that for securing continuity of service duplicate, if not triplicate, cables are necessary, quite apart from the double or three-fold carrying capacity; and a single cable carrying ten times the traffic would by no means replace the ten cables which are now at work in the North Atlantic. Meanwhile, the problem, from a scientific point of view, is of the highest interest, and both cable men and telephone men will have to give it careful consideration.

We print, this week, a detailed account of experiments on the use of a magnetic shield for preventing appreciable disturbance of the magnetic instruments at Greenwich by the stray field of a dynamo. There are several points of considerable interest in these experiments. The action of one magnet on another is generally treated from the magnetometer point of view in text-books, the length of the deflecting magnet introducing a little complication. But when the distance of the deflected magnet is large compared with this length, and the deflections are small, the deflecting force is approximately inversely as the cube of the distance. This was confirmed by the experiments. The effect of this shield, though on a small scale, is interesting in connection with the disturbances likely to arise in connection with electric railways. Though the dynamo gave only two kilowatts, the observing instrument, a Kew unifilar magnetometer, is extremely delicate. The final result, a deflection of only half a second of arc of the declination magnets in the Greenwich Observatory is very satisfactory.

One of the advantages of the State administration of the postal and telegraph services is that the regulations can be cast into a uniform shape, and are easily accessible. Were the post office and telegraphs, like the railways, parcels delivery companies, and telephones conducted by private enterprise, while we might gain much by competition, we should lose in simplicity. The "Post Office Guide" is a book which requires a good deal more knowledge to use than the so-called "Post Office Directory," but it is distinctly less complicated than Bradshaw. A rather indignant letter to *The Times* last week reveals a deficiency in this useful publication. Somebody wanted to send a telegram on Sunday, and was informed that the telegraph office at the destination was closed. The postal officials were apparently unable to tell him the name of the nearest town, where the telegraph office was kept open to the later hour, nor *a fortiori* the porterage from this unknown town to the destination. The writer, thereupon, asked for a map, and the theme of his loud complaint is that no map showing the telegraph stations is in existence. The British Government does not distinguish itself in map-making, and a little reflection shows that a county atlas rather than a map would be wanted, as the difficulty arises in connection with the smaller towns and villages.

The "Post Office Guide" gives a list of all villages having any kind of post office, together with the name of the nearest delivering telegraph office, and its distance in miles. Near the end of the book, as though a protest against Sunday work, is a list of the offices which are open beyond the usual hours on Sundays, or are open always. But if the sender of a telegram, looking up the nearest telegraph office to his village does not find it in this Sunday list, there is no more information for him. All that is wanted is the addition to the first list, of the name of the nearest telegraph office open on Sundays to a late hour, with its distance. There are only nine offices in London, twenty-two in the rest of England, five in Scotland, and five in Ireland, open always. *The Times* thinks that it would be "perfectly easy to make arrangements whereby it should never at any time, night or day, Sunday or week-day, be impossible for any one office in

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the Kingdom to gain the attention of any other office." The first arrangement that suggests itself is a gun, semaphore and rocket apparatus on the top of each country post office, a rule that the telegraph operator shall never take a Sunday afternoon walk out of earshot or sight of the said apparatus, and that the sender shall pay a fee to be handed to the said operator as compensation for spoiling the said Sunday afternoon walk.

THE opposition of the Leicester Ratepayers' Association to the proposed municipal electric lighting undertaking, which at one time appeared to be meeting with considerable support, scarcely justified its existence at the Local Government Board inquiry, held on Friday last. On the other hand, if public opinion be in reality in favour of municipalising anything and everything, then no particular harm can come from dropping once and for all the old bogey of huge purchase-price that will one day have to be paid to private monopolists, unless electric lighting is straightway municipalised. Thus in his address to the Inspector, the Town Clerk of Leicester justified the step contemplated by the Town Council by "the experience they had already had in Leicester in reference to private companies," and instanced the 116 per cent. premium paid to the Gas Company, and the 97 per cent. premium paid to the Water Company for compulsory purchase. Such an argument from the past is, in face of Section 2 of the Electric Lighting Act of 1888, entirely beside the point. According to an eminent authority, the result of Section 27 of the Act of 1882, which is, in principle, the counterpart of its successor in the later Act, will be that those private capitalists who embark in an electric light undertaking will, on the one hand, run all the risks of failure of every kind and description, and on the other receive nothing whatever for the business built up, should it happen to prove a success and the local authority take a fancy to it. That this is so, no one who has studied the subject can doubt. The inference seems, therefore, to be irresistible. Either the advocates of municipal electric lighting do not trouble to read the Acts relating to it or, suspecting lack of enthusiasm on the part of the ratepayer, they try to frighten him with the bogey aforesaid. Much can be said for and against municipal electric lighting, but neither the argument for nor the argument against will suffer from being based on fact.

THE disinterested philanthropist who is going about the country selling "electric" spectacles at a guinea a pair is obviously a raw hand. "*L'audace, encore de l'audace, toujours de l'audace*" is an excellent maxim for quacks, but when desirous of securing complete immunity from newspaper comment and criticism they have need of another. Had this vendor of "electric" spectacles, warranted to simultaneously cure sore eyes and rheumatism, taken care to "advertise cleverly, advertise lavishly, and advertise always," the letters which have been allowed to appear in the daily Press denouncing his malpractices, and the editorial utterances that have supplemented these letters, would, the dull season notwithstanding, have been irrevocably committed to the bourn whence no copy returns—the editorial waste-paper basket.

Inter-Urban Telephony.—The telephone traffic between Paris and Havre has increased so much that a third circuit has been rendered necessary.

Cable Interruptions:

	Dates of Interruptions.
Aden-Zanzibar	August 9th.
Falmouth-Bilbao	„ 17th.

Harrogate.—At a meeting of the Town Council on Monday it was decided by thirteen votes to seven to undertake the electric lighting of the town.

Halifax.—A Local Government Board Inquiry was held last week relative to the proposed Corporation electric lighting loan of £30,000. The scheme was opposed by the Halifax Mutual Electric Light and Power Company.

Bolton.—Major-Gen. Crozier, one of the inspectors of the Local Government Board, conducted an inquiry at Bolton on Tuesday into the application of the Corporation to secure power to borrow £40,000 for electric lighting works.

A New Chair of Applied Electricity.—It is announced by the French Minister of Public Works that a Chair of Applied Electricity has been instituted at l'École Nationale des Ponts et Chaussées, the Parisian college of civil engineering.

Manchester.—At a meeting of the Town Council last week the report of the Highways Committee with regard to the question of underground telephone wires, which was summarised on page 357 of our issue of August 4th, came up for adoption. An amendment to the effect that more time be allowed to consider the question was carried.

Copper.—During the past fortnight deliveries in England and France exceeded supplies by nearly 1,000 tons, and the total visible supply now amounts to only 49,557 tons, compared with 50,483 tons on July 31st. The price of copper, however, continues to fall, and Chili bars are now quoted at £41. 2s. 6d. a ton, or 10s. a ton lower than a fortnight ago.

The City Polytechnic.—Courses of evening lectures and practical instruction in mechanical engineering, machine design and drawing, by Mr. Henry Adams, will be commenced at the City Polytechnic, City of London College, early in October. There will also be courses of instruction in electricity, mechanics, mathematics, and other sciences relating to electrical engineering.

Engineering Education.—One of the divisions of the Engineering Congress, which held its meeting at the Chicago Exhibition from July 21st to August 4th, was that of Engineering Education. Twenty-two Papers were read, a number of which had more or less bearing on the education of electrical engineers. A permanent organisation has been effected under the name of the "Society for the Promotion of Engineering Education."

The Hermite Sewage Process.—Advantage is going to be taken of the forthcoming Hygienic Exhibition at Havre to carry out on a large scale the Hermite electric disinfection process. M. Hermite's process, which was described in *The Electrician* at the time of its inception, consists simply in the electrolysis of sea water, the electrolysed liquid being used to flush the sewers. During the Exhibition a section of the Havre sewers will be treated in this way.

Arc Light Accident at Leeds.—An inquest was held this week at Leeds on George Sykes, 21, an electrical engineer employed on the Midland Railway, who died at the Infirmary from a fall caused by an electric shock. He was attending to a lamp in the goods yard, and put his hand inside. A flash occurred, causing him to fall from a ladder, fracturing his skull and spine. He had neglected to put on indiarubber gloves. Verdict of accidental death was returned.

The International Electrical Congress.—Our New York correspondent, writing under date of August 11th, states that all the foreign delegates to the International Electrical Congress, at Chicago, had either arrived or were on their way. The complete list is as follows:—United States, Rowland, Carhart, Mendenhall, Nichols, and Elihu Thomson; England, Ayrton, Preece, Cardew, Siemens, and S. P. Thompson; Germany, Helmholtz, Schraeder, Voit, Lummer, and Budde; France, Mascart, Hospitalier, De la Touanne, and Violle; Italy, Ferraris.

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The City Lighting.—We trust that those responsible will take warning:—If the statement be true that the City Commissioners of Sewers contemplate removing the street gas lamps on an early date, it is, thinks the *Gas World*, an intention that says little for their wisdom. "It is not many weeks since we had occasion to report an extensive failure of the arc lamps that are supposed to be a perfect substitute for the gas lamps. To even talk about removing the gas lamps while experience shows that the probability of such failures has to be reckoned with is folly, and to remove them would be almost sheer madness."

Alternative Telegraph Lines.—The advantages of alternative lines of telegraph, says the *Indian Engineer*, have been strikingly illustrated during the present monsoon season. The direct line from Calcutta to Assam has been broken, owing to floods between Jalpaiguri and Dhubri, two rivers at least having changed their course and washed away the masts from which the wires are suspended at the crossings. Messages have consequently had to be sent by another route pending repairs, and the only one available is by way of Burma. It is a long distance round through Mandalay and Tammu, but the work has been satisfactorily disposed of, the Telegraph Department, as usual, being readily equal to emergencies.

Transmission of Power in Switzerland.—An important scheme for the transmission of power is now being considered in Switzerland. It is proposed, says *Engineering*, to dam the River Reuse and convey the water to a storage and distributing reservoir having a capacity of 3,000,000 cubic feet, and situated at Combe Garrot. From here the water is to be distributed to the communities of Neuchâtel, Loche, and La Chaux-de-Fonds. The head available will be about 300ft., and the conduits will have a capacity of 177 cubic feet per second, though the flow of the river varies between 100 and 60 cubic feet per second only. The power will be distributed from the turbine stations by electricity, the distances being from 7½ to 11 miles.

Wind Power.—Some years ago an attempt was made under the auspices of the Duc de Feltre and M. L. Vigreux to drive the dynamos at the Pointe de la Hève Lighthouse by wind-power. The wind, however, as is its custom, blew when and where it listed, and ended one fine, or rather one stormy, day by overthrowing the ungainly apparatus installed on the exposed headland. M. Max de Nansouty, in alluding to this attempt to "harness" the wind, suggests that next time a similar attempt is made it would be as well to try the effect of surrounding the "atmospheric turbines" by strong towers, and directing the wind on to the vanes by nozzles in much the same way as the water is directed on to the buckets of a Pelton wheel. This idea of "canalising" air currents is, it is said, actually engaging the attention of windmill experts.

Electric Launches.—Much, very much, says the *Engineer*, is said in the Press occasionally about the advantages of electricity as the motive power for launches, &c. Enthusiastic persons talk and write about an electric torpedo boat. There is something which appeals very strongly to the imagination in the idea of a boat urged along at a high speed, making no noise, emitting neither sparks, nor smoke, nor smell, to indicate its whereabouts. That a torpedo boat which would do this would be an acquisition to any navy, now goes without saying. As a means of converting electrical energy into mechanical work an electric motor is practically a perfect machine. Could we stow the electrical energy in receptacles one-tenth the size and weight of the present storage cells, and did the operation take about one-tenth of the time now occupied, there would be no need to discuss the most suitable motor. The difficulty is with the cells.

Telephone and Telegraph Wires at Brighton.—At the meeting of the Brighton Council last week, on the Works Committee report coming up for adoption, Councillor Sutton, referring to the decision of the Committee to comply with an application of the Postal Telegraph authorities for permission to open the roadway in North-street for the purpose of underground telegraph wires, asked whether this excavation could not be made final so that the inhabitants of North-street might have a little rest from such nuisances. Councillor E. A. Dell thought the Corporation should compel the telegraph authorities to lay their wires at night time or refuse to allow the work to be carried out at all. On the draft of bye-laws with respect to telephone and telegraph wires over public streets being brought forward for confirmation, Councillor E. A. Dell asked whether he had any legal power to cut the telephone wires that ran over his premises, if he thought fit, and was answered in the affirmative.

Electric Lighting and Fire Risks.—Statistics of the conflagrations in the United States during the last year have recently been analysed by M. Boudinet, who has shown that out of the 17,095 fires in 60 large towns only 203 have been caused by electricity, and that out of the total damage of $22,781,532 which has resulted from these fires only $281,241 have been lost on account of injury wrought by electric currents. It must be remembered that in the United States electricity is far more used for general purposes than in this country, and that careful work is not so common there as it is here. Thus, with a widespread use of this mode of lighting and transmitting power, not more than 1·19 per cent. of the fires and only 1·23 per cent. of the damage can be attributed to its use. Of the 203 fires due to electrical causes 59 occurred in New York, 26 in Boston, 16 in Cleveland, 12 in Lowell, 11 in Minneapolis, and 10 in Philadelphia.

Terrestrial Magnetism.—An interesting note on the variation of the earth's magnetism in the neighbourhood of a hill containing magnetic rocks, by MM. Oddone and Franchi, has, says *Nature*, appeared in the "Annali dell' Ufficio Centrale di Meteorologia e Geodinamica" (Vol. XII., part I.). The hill was composed of serpentine, and had, roughly speaking, a lenticular shape, being 1,500m. long, and 500m. broad, with its greatest length north-west and south-east. The declination is the only element up to now observed. As an example of the magnitude of the deviations obtained we may give the following set of readings (corrected for diurnal variation), along a line running north-east from the hill. At the out-crop of the serpentine the reading for the needle was 11deg. 20min.; about 100m. away, 10deg. 35min.; about 500m. away, 9deg. 56min. 30sec.; while at a distance of 700m. it was 9deg. 50min. 30sec. In every case an attraction of the north pointing pole of the needle towards the serpentine was obtained, thus indicating that the mass of rock was magnetised with its upper end a south pole.

Alternating Currents of High Pressure.—At a recent meeting of the Société Française de Physique a communication was made by M. Leduc on the production of high-pressure alternating currents by means of electrostatic influence machines. Experiments were carried out with the aid of a 2-plate Wimshurst machine. The alternating currents obtained in this way possess properties analagous to, but not identical with, those upon which Tesla has been making researches. Conductors traversed by these currents became luminous, and, by varying the shape of the conductors, or by approaching them with other conductors, a variety of beautiful luminous effects are produced. The best arrangement is that in which one of the external armatures is connected to earth, the other being connected by means of a chain to the table of the machine. When this chain is enveloped in a length of caoutchouc tube and held in the hand, a phosphorescent light is produced between the tube and the hand. These currents when passed through the human body are found to act on the motor and sensory nerves, while Teslaic currents do not.

The "Tromometer."—Electricity has either in imagination or in fact been pressed into many strange services, but we doubt whether it has performed anything more curious than it does in the case of the "tromometer," which is an instrument devised by a M. Quintard, of Angers, to determine the degree of shakiness or steadiness of the human hand. The "tromometer" consists of a knitting needle and a sheet of metal pierced with a series of gradually diminishing holes. One pole of a battery is connected to the knitting needle, the other to the draw plate, an electric bell being also in circuit. The "subject" has then to insert the needle through the holes in succession, beginning at the largest, until the amplitude of his "shakes"

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is such that he ends by touching the sides of the hole, a result which is announced to the world at large by the ringing of the electric bell. It is suggested that a "tromometer" would be a useful adjunct to the equipment of a competing rifleman; unfortunately for this idea, steadiness of hand and accurate shooting do not by any means go together, so that the indications of a "tromometer" would, as likely as not, be a cause of unnecessary discouragement.

Electric Lighthouses.—At the recent session of the International Maritime Congress several Papers of interest to electrical engineers were read. Among these we may notice a Paper by Mr. Stevenson on lighthouses, which describes the works which have lately been carried out for improving the lights on our coasts. In the discussion which ensued, the relative merits of gas, oil, and electricity, for illuminating purposes were considered. It has long been supposed that the last-named mode of lighting, while superior to the others in clear weather, is incapable of producing penetrating rays when the weather is foggy. The results of experiments which have been carried out by the Lighthouse Commission would tend, however, to show that this opinion is mistaken; and that electricity, on account of the direct penetrating power of the light as well as because of its more complete reflection from the clouds, is the most satisfactory means of lighting for coast lighthouses. Mr. Wigham, who took part in the discussion, considers it of such great importance that this point should be carefully determined, that he has offered to the Irish Lighthouse authorities to carry out at his own expense a series of experiments on lights to be fixed in Dublin Bay.

The Post Office and the National Telephone Company.—At a meeting of the Telephone Committee of the Glasgow Town Council on Tuesday the proposed agreement between the Postmaster-General and the National Telephone Company, by which it is thought the streets of the City would practically be handed over to the Company, was under consideration. It was agreed, in order to strengthen the hands of the City Members of Parliament in preventing the agreement being completed, to send two members of the Telephone Committee to London to have an interview with the Postmaster-General. We understand, says the *Glasgow Herald*, that the Association of Municipalities is moving in the direction of supporting Glasgow and other corporations in insisting that the Postmaster-General should make known the terms of agreement with the Telephone Company before signing it; also to oppose the Company getting any powers beyond what they at present possess. An engineer, it is further stated, has written to a member of the Telephone Committee to the effect that there is reason to believe that the National Telephone Company have so negotiated the agreement that it will be found that corporations will be placed at a vast disadvantage, and that the agreement will virtually confer on the National Company a monopoly of telephone exchange work in the country. The agreement must, he says, in the public interest, be laid before Parliament *unsigned*.

Pioneer Inventors.—Much space, more or less valuable, says the *Electrical World* of new York, has been, and probably will continue to be, devoted to accounts of "pioneer inventors"—accounts which are usually couched in highly eulogistic terms, sometimes even approaching the hysterical in expression. We use the expression "pioneer inventors" in its paradoxical sense as applied to those who first pointed out or made use of an obvious application that involved no exercise whatever of the inventive faculty. To particularise, we will suppose that once upon a time a man saw a small electric motor, then very rare, in operation, and noticed that its shaft revolved; he is also aware of the fact that other shafts revolve, and it occurs to him that by hitching a motor to one of these other shafts it will be revolved by the motor. Acting on the thought, he makes a model, perhaps astonishes some of his neighbours, and that is the last of it as far as he is concerned. Many years later, when motors have assumed a commercial form, and are generally employed, the model is brought to light, a journalistic writer gets up an article with many illustrations, including, perhaps, a portrait, a view of the man's former residence and of his grave; the world's ingratitude to its great inventors is enlarged upon, or a quotation from Gray's "Elegy" neatly worked in, and another name is added to the list of pioneer inventors. Most of the accounts of pioneer inventors would be merely amusing were it it not for the fact that the claims made are eagerly accepted by writers of popular books on account of the supposed interest they will give their narrative, with the consequence that the credit of the real inventor is diminished, or perhaps entirely lost sight of.

Electric Search-Light Applied to Pit Sinking.—In a Paper recently read before the Mining Institute of Scotland, Mr. James Baird described an electric search-light, which has been applied to pit sinking near Paisley. The apparatus, which is suspended over the pit's mouth, consists of an arc lamp, a lens, and a mirror, the whole being enclosed in a sheet iron case, 4ft. 9in. by 1ft. 8in., by 1ft. 8in. Access to the lamp is obtained by a sliding shutter on each side of the case. The light is focussed or adjusted by a screw on the top of the outside of the case, and when occasion requires the lamp can be adjusted to diffuse light throughout the whole shaft, or be concentrated at the bottom, where the men are working. The mirror is hung on its centre, and can be moved in a vertical direction, so as to deflect the rays of light to where they are wanted, after which it is held in position by a thumb-screw. The shaft at Walkinshaw is circular, 13ft. in diameter and 43 fathoms deep. It is lined with brick all the way. From Mr. Baird's experience he found that the following advantages were obtained with the lamp:—(1st.) The light at the shaft bottom was far in excess of that got from the ordinary sinker's lamps, consequently more work could be performed in a given time. (2nd.) The lamp being stationed on the surface could be got at easily at any time for adjustment without inconvenience to the sinkers; and in the event of the strata giving off fire-damp, it would give perfect immunity from danger of explosion. (3rd.) By the aid of the light those in charge could see from the surface what was going on below, and this is not altogether an unimportant matter; in fact, a practical gentleman visiting the colliery was delighted with this aspect of the light, and said that it was worth all the outlay, even if it served no other purpose than this.

Whitworth Scholarships.—The following candidates have been successful in the competition for the Whitworth scholarships and exhibitions, 1893:—

Name.	Age.	Occupation.	Address.	Value of scholarships and exhibitions awarded.
(1) Scholarships (tenable for 3 years)				
Hamilton, William ..	23	Electrical engineer	Glasgow ..	£125 a year each
Longbottom, J. G...	23	Engineer	Keighley ...	
Malpas, Arthur E....	22	Engineer	London	
Durley, Richard J..	25	Engineer	London	
(2) Exhibitions (tenable for 1 year)				£
Smith, Charles F. ..	20	Mechanical engineer ..	Glasgow ..	50
Ball, John	21	Student.....	Derby	50
Buchan, William ...	21	Engineer	Glasgow ...	50
Chambers, John B..	19	Engineer's apprentice	London	50
Loveridge, Henry J.	21	Engine fitter	Southsea ...	50
Ireland, William F...	25	Draughtsman	Glasgow ...	50
Fearnley, George W.	21	Student.....	Shipley	50
Styles, Oliver	23	Engineer student.. ...	Edinburgh ..	50
Russell, George M. ..	21	Shipwright apprentice	Portsmouth.	50
Jude, Alexander A...	17	Engineer's apprentice.	Hull	50
Amor, Edward R. ...	17	Engine fitter „	Devonport ..	50
Jeffrey, Joseph... ...	25	Engineer's student ...	Birmingham	50
Reynolds, Paul J. ...	19	Fitter	Plumstead...	50
Pilkington, Thomas..	25	Fitter	London	50
Reynolds, Richard..	24	Fitter	Cardiff	50
Wilson, George	21	Mechanical engineer..	Sheffield ...	50
Hammant, W. O. ...	20	Fitter	Plumstead ..	50
Orr, John	23	Engineer's apprentice.	Airdrie	50
Chubb, I. William...	22	Draughtsman	London	50
Smith, Henry.....	21	Engineer's apprentice	Brighton ...	50
Green, Frederick D.	21	Engineer's apprentice	Wanstead E.	50
Powell, John	21	Fitter	Crewe	50
Hardy, James H. ...	24	Mechanic	Woodley ..	50
Shepherd, James H.	23	Draughtsman	Swindon ..	50
Thompson, Herbert..	23	Engineer	Sheffield ..	50
Stephens, Evan	23	Draughtsman	Swindon ...	50
Morrall, Henry E. ...	20	Draughtsman	Wolverton ..	50
Bates, Herbert	18	Fitter	Manchester..	50
Hill, Charles H.....	20	Engineer's apprentice	Stratford E.	50
Massey, William F...	24	Mechanic	Newport ..	50

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ELECTROMAGNETIC THEORY.—LIII.

BY OLIVER HEAVISIDE.

(Continued from page 257.)

§ 208. The detailed application of the principles already discussed to the data which occur in practice, or which may occur in later practice, would lead us into technical complications which would be out of place in the present stage of development of this work. Only a few general considerations can be taken up here in connection with the theory of plane waves. We have seen that there are four distinct quantities which fundamentally control the propagation of "signals" or disturbances along a circuit, symbolised by R, K, L, and S, the resistance, external conductance, inductance, and permittance; whilst there are two distinct variables, the transverse voltage V and the circuital gaussage C, or the difference of potential (in an extended sense) of the leads in a reference plane, and the current in the leads. The words voltage and gaussage were proposed in § 27 to represent electromotive force and magnetomotive force, and have been employed experimentally to see how they would work. They work very well for theoretical purposes, but I observe that they are not generally or universally approved of, perhaps on account of the termination "age," or because of the commencements volt and gauss being unitary names. It is open, of course, to anyone to find names which shall be more suitable or meet with general approval.

But I stick to inductance. Of all the words which I have proposed, that one seems to me to be, more than any other except impedance and conductance, the right word in the right place, and I am bound to think it possible that some of those who prefer the old "coefficient of self-induction," do not fully appreciate the vital significance of inductance in a theory of intermediate action of a medium. The idea of the direct mutual action of current-elements upon one another is played out. And as regards the name of the practical unit of inductance, I think the best name is mac, in honour of the man who knew something about self-induction, of course. Many other names have been proposed, but none so good as mac. Some critic has made etymological objections. But what has etymology got to do with it? The proper place for etymology is the grammar book. I always hated grammar. The teaching of grammar to children is a barbarous practice, and should be abolished. They should be taught to speak correctly by example, not by unutterably dull and stupid and inefficient rules. The science of grammar should come last, as a study for learned men who are inclined to verbal finnicking. Our savage forefathers knew no grammar. But they made far better words than the learned grammarians. Nothing is more admirable than the simplicity of the old style of short words, as in the "A sad lad," "A bad dog," of the spelling book. If you transform these to "A lugubrious juvenile," "A vicious canine," where is the improvement?

Now, as we have already explained the characteristics of distortion of plane waves by conductance in the medium generally, of two kinds, acting differently on the electric and magnetic fluxes, the corresponding relations in a long circuit of leads need be only briefly mentioned. Consider an infinitely long circuit of parallel and equal resisting leads under uniform external conditions, and governable by the relations laid down. Let it be, at a given moment, wholly free from charge or current except at one place, where there is merely a charge, say Q_0. Or, say $Q_0 = SV_0$ on unit length only at the place. Left to itself, this will spread. But it will do so in widely diverse manners under different circumstances, although there are some common characteristics. The speed of propagation of disturbances is $v = (LS)^{-\frac{1}{2}}$, independent of the values of R and K, the dissipation constants. Thus, at time t after the spreading begins, we are bound to find the charge, or what is left of it, within the region of length $2vt$, being vt on each side of the origin. Beyond this region there is no disturbance.

Next as regards the amount of the charge. It cannot increase, but it may diminish. If the insulation be perfect, which means that K = 0, the charge remains constant. It is unaffected by the resistance of the leads, although energy is wasted in them. It only decreases by the external conductance, or by equivalent leakage. Then we have

$$Q = Q_0 \epsilon^{-Kt/S}, \quad \ldots\ldots (1).$$

to express the charge Q at time t, decreasing according to the well-known exponential law.

As regards the manner of spreading, either with or without the subsidence, this is represented in the exact theory by the spreading and subsidence of displacement in a medium which is magnetically as well as electrically conductive, although the former property does not affect the total amount of displacement. We see, therefore, that the distortionless case, which occurs when the time constants L/R and S/K are equal, forms a natural division between two distinct kinds of resultant distortion. In this neutral case, the charge Q_0 splits into two halves which at once separate from one another at relative speed $2v$. At time t later they are each attenuated to

$$\tfrac{1}{2}Q = \tfrac{1}{2}Q_0 \epsilon^{-Kt/S}. \quad \ldots\ldots (2).$$

The energy was wholly electric to begin with, but in each of the resulting waves it is half electric and half magnetic, because they are pure waves. As they attenuate, their energy is wasted, and this occurs so that half is wasted by the resistance of the leads, and half by reason of the external conductance. This is necessary in order that a pure wave shall remain pure. The final result is attenuation of the two charges to zero, when they are infinitely widely separated, and with this a complete simultaneous disappearance of the other characteristics, as the magnetic force. In the exceptional case of no resistance and no leakage, there is, of course, an everlasting persistence of the two charges and of the waves of which they form a feature. They go out of range, but not out of existence. In all other cases but the distortionless one, the charge (or the remains of the original charge) is only partly in the plane waves at the two ends of the disturbed region, the rest being diffused between them. But this may happen in two ways. The total charge at time t is expressed by (1) above. But the charge in the terminal waves, half in each, is given by

$$Q_0 \cdot \epsilon^{-(R/2L + K/2S)t}, \quad \ldots\ldots (3)$$

reducing to (2) doubled in the distortionless case. Therefore the excess of (1) over (3) is the amount of the diffused charge. It is

$$Q_0 \cdot \epsilon^{-Kt/S}(1 - \epsilon^{-(R/2L - K/2S)t}), \quad \ldots (4)$$

and is positive or negative according as R/L is greater or less than K/S.

That is, when the resistance of the leads is in excess, the charge is positive between the waves as well as in them. But when the leakage is in excess the intermediate charge is negative. This happens equivalently when the inductance is in excess, or the permittance in deficit. How this reversal comes about has been already explained in the exact theory. In the present circumstances we may say that an intermediate resistance in the circuit of the leads reflects V positively and C negatively, whilst an intermediate leak reflects C positively and V negatively. The same applies to the elements of the circuit, and from this follows the reversal of V when leakage is in excess. Whether the tailing be of the usual positive or of the negative kind (referred to the charge), the maximum or minimum density is in the middle; that is, at the origin. The density decreases symmetrically both ways to the two ends, where the plane waves are to be found. When they have attenuated to practically nothing, there is left merely the widely diffused charge, unless it has attenuated similarly. With the resistance largely in excess, there may be nearly all the charge left when the terminal waves have become of insensible significance. But if the leakage be in excess, the disappearance of the terminal waves is accompanied by a similar disappearance of the intermediate negative charge, because the total charge is always positive.

So far regarding the spreading of a charge, next consider the spreading of induction. The magnetic analogue of Q is P = LC, the magnetic momentum per unit length of circuit. So, as L is constant, the spreading of P is represented by that of C. Suppose initially there be current C_0 in unit length at the

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origin, with momentum $P_0 = LC_0$, and no charge there or elsewhere. This also splits immediately into two plane waves, which only differ from those arising from a charge in having similar C's and opposite V's instead of similar V's and opposite C's.

The total induction remains constant only if the leads have no resistance. In general it decreases, so that at time t we have

$$P = P_0 \cdot \epsilon^{-Rt/L} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

At the same time the amount in the terminal waves, half in each, is

$$P_0 \cdot \epsilon^{-(R/2L + K/2S)t} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

The amount between the terminal waves is, therefore, the excess of (5) over (6), which is

$$P_0 \epsilon^{-Rt/L} \left(1 - \epsilon^{-(K/2S - R/2L)t}\right) \quad . \quad . \quad . \quad (7)$$

These equations (5), (6), (7), may be instructively compared with the set (1), (3), (4), their analogues. Notice that in transforming from one set to the other, we exchange V and C, Q and P, R and K, L and S. In the exact theory the R in these formulæ would also be a conductance, as before described.

By (7) we see that in the distortionless case all the induction left is in the terminal waves, which is to be expected. But we require the leakage to be in excess for the intermediate induction to be positive, and conversely the resistance must be in excess for it to be negative. Of course, the initial induction is assumed to be positive. Also observe that leakage by itself has no effect on the total induction except to redistribute it, just as the resistance of the leads has no attenuating effect on the total charge. As before, the maximum or minimum density of induction is at the origin, though, of course, the terminal inductions may have greater or smaller density than this, according to the extent of attenuation at the moment concerned. Remember that the destruction of induction by the resistance of the leads is represented, in the exact theory, by its destruction by the equivalent magnetic conductance externally.

Putting together the preceding results, we may readily see the effect of having both V and C initially at any spot. One case is specially noteworthy. Take $V_0 = Lv C_0$ initially. This means a pure plane wave sheet, travelling in the positive direction. There is, therefore, no initial splitting, and the wave just goes on. To what extent this will continue depends upon the relation the constants of the circuit bear to the distortionless state. When the latter obtains, the wave is transmitted without spreading out behind, so that at time t the initial state, if existent over unit length, will be found over unit length at distance vt to the right, attenuated to

$$V = LvC = V_0 \epsilon^{-Rt/L}, \quad . \quad . \quad . \quad . \quad (8),$$

where for t may be substituted its equivalent x/v. In all other cases there is reflection in transit, and the reflected portions travel back, besides getting mixed together, thus making a tail of length $2vt$, half on each side of the origin, but now, of course, without a head at the negative end to balance the one at the positive end.

If the resistance be in excess, the charge in the tail is positive and the current is negative, at least initially; whilst if the leakage be in excess, the current is positive and the charge initially negative. *See* §§ 195 to 199 for more details, which may be readily translated to suit the present case. The total charge subsides according to equation (1) above, and the total induction according to (5). Similarly (3) represents the charge in the one terminal wave (instead of both, as there), and (6) shows the induction in the terminal wave.

If initially $V_0 = -LvC_0$, this means a negative wave (going to the left) to start with. This needs no separate notice in detail.

§ 209. The distortionless state forms a simple and natural boundary between two diverse kinds of propagation of a complicated nature, in each of which there is continuous distortion which is ultimately unlimited. Given time enough, and a circuit of infinite length to work with, the least departure from the distortionless condition would be sufficient to allow all the natural changes to be gone through, with ultimate unlimited distortion. The attenuation is a separate matter in this connection, though itself of great importance. If, however, we are only concerned with the distortion produced in a finite interval of time, which may be quite small, then the matter may be differently regarded. There is much or little distortion, generally speaking, according as the ratios R L and K/S are nearly equal or widely different. But this needs to be understood with caution, for obviously there may be next to no distortion of signals even when the distortionless state is widely departed from, provided the changes of charge and current are made slowly enough. But when this is not the case, and there is marked distortion of waves in transit, then we shall increase it by making the time-constants more unequal than they are, and decrease it by a tendency to equalisation. Furthermore, this process is a continuous one, so that, starting from the distortionless state connected with equal time-constants, we may, by continuously increasing one time-constant, bring on continuously increasing distortion of one kind, or else, by increasing the other, whilst the first is kept constant, bring on continuously increasing distortion of the other kind. And this is true by variation of any one of the four quantities concerned, the resistance, leakage, inductance, and permittance, to prove which we need only remark that with any values given to these constants we can equalise the time-constants and abolish the distortion altogether by altering any one only of the four.

When a circuit has been brought to this state, then arbitrary signals of any size and manner of variation, originated at the beginning of the circuit, will run along it at the speed of light, and in doing so suffer no alteration save a weakening according to the exponential law given above. The voltage and gaussage at any spot will be always in the same phase, and the succession of values will faithfully repeat those at the origin. If the circuit be infinitely long, the train of disturbances will run out to infinity, of course, though it may be still a long way from infinity when the attenuation is so great as to make the disturbances insensible. Therefore, disregarding the attenuation, there is no limiting distance of possible signalling. More than that, it is not only possible, but perfect signalling, according to this theory.

But there is no perfection in this world. Even if a circuit were constructed with constant R, K, L, and S, and with R/L = K/S exactly, so that it should be truly distortionless in this practical theory, it would not be so in reality. There are several disturbing causes, which, though they might not be of much importance in general, would serve to prevent the attainment of the clean-cut perfection of the theory which ignores them. Instead of zero distortion, then, it is practically only a state of minimum distortion that is attainable. But it may be a very good imitation of the theoretical ideal. It is unnecessary to enlarge upon the necessary failure of a professedly approximate theory when pushed to extremes. It is sufficient to say that the ignored disturbing influences alone would serve to set a practical limit, even if the condition R/L = K/S were truly attained, and attenuation were of no importance.

But there is an influence in full action in the practical theory itself which must not be overlooked, namely, the attenuation due to resistance and leakage. Of what use would it be to have a distortionless circuit if it took nearly all the life out of the current in the first 100 miles, when you want it to go 1,000? Now, on paper nothing is easier than to increase the battery power to any extent you want, till, in fact, the minute fraction which got to the desired distance became magnified up to a recognisable size. But practically there would usually be strong reasons against this process. At any rate, it is impossible to overlook the attenuation. It is not merely enough that signals should arrive without being distorted too much, but they must also be big enough to be useful. If an Atlantic cable of the present type were made distortionless by the addition of leakage, there would be no sign of any signals at the distant end with any reasonable battery power. Nor can we say that telephony is possible on a circuit of given type to this or that distance merely because a certain calculable and small amount of distortion occurs at that distance. Nor can we fix any limiting distance by consideration of distortion alone. And even if we could magnify very weak currents, say

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a thousandfold, at the receiving end, we should simultaneously magnify the foreign interferences. In a normal state of things interferences should be only a small fraction of the principal or working current. But if the latter be too much attenuated, the interferences become relatively important, and a source of very serious distortion. We are, therefore, led to examine the influence of the different circuit constants on the attenuation, as compared with their influence on the distortion.

(To be continued.)

OCEAN TELEPHONY.*

BY SILVANUS P. THOMPSON, D.SC., F.R.S.

I.—Introductory.

It is contrary to the scientific spirit of progress to admit that any art or application of science can stand still, or that any of its developments are final. To bridge the ocean by an electric telegraph was a mighty achievement. To speak through a wire the audible syllables of language was a marvel. To accelerate telegraphic transmission by automatic devices until a speed of even 500 words per minute was attained was a bewildering accomplishment. But with the attainment of these three tremendous strides, finality has not been reached. The ocean cable of to-day is practically unchanged from what it was thirty years ago. It speaks only with the still slow signals of the mirror galvanometer, or of the siphon recorder. Six or eight words per minute slowly spelled out are the usual limits of working of an Atlantic cable. The spoken telephonic word, and the rapid automatic telegraphic message are too nimble for it. For such rapid signalling it is dumb. That a submarine cable clad in its coating of gutta-percha would retard the rate of signalling was predicted by Faraday, and verified when the first long cable was laid. Many have been the subsequent devices to increase the speed of signalling by the use of condensers and the like. They have all been devices to be applied either at the transmitting, or at the sending end, or at both. Arrangements of condensers and resistances so combined as to act as an artificial cable, imitating the retardations of an actual cable, have been found indispensable adjuncts for balancing the properties of the cable in order to adapt it for duplex working. Varley proposed, many years ago, another device, namely, to introduce at each end an inductive shunt; that is to say, to apply as a shunt a wire possessing both resistance and self-induction. But in spite of the use of condensers, of artificial cables, and of inductive shunts, the retardation of the long submarine cable has proved hitherto insuperable save for slow signals. In the sending of each signal the gutta-percha coating becomes charged, and this charge must be, as it were, swept out before the next signal can be sent. Retardation triumphs over the telephone and the automatic rapid telegraph.

And yet no reasonable electrician can doubt for a moment that ocean telephony must come, or that the resources of science are equal to the solution of the problem. It is because the author thinks that he has found the way to the solution that he ventures to place on record the ideas which have been growing in his mind for three years past, together with some of the evidence by which their soundness may be tested.

If the solution at which he has arrived seems strange to the ordinary telegraph electrician or cable engineer, it is because that solution has dawned upon him out of a different domain of science, namely from the study of alternate-current phenomena. If the solution he now propounds seems impracticable to cable engineers accustomed to the old type of cable that has persisted now for 30 years, he would reply that it is the business of the engineer to make it practicable. If the business of the world demands a new type of cable then the engineer must be found who can manufacture and lay it. Seeing that such a cable, once laid, will (if the author's views are correct) perform the work at a rate that would at present require, say, 10 ordinary cables to perform, there is a very powerful inducement to the engineer to find a practicable way of realising that which theory indicates as the submarine cable of the future.

* Paper read before the International Electrical Congress at Chicago, August 22nd.

II.—Devices to Neutralise the Retarding Effects of Capacity in Submarine Cables.

The retardation of signalling, which is found in submarine cables, is due to the capacity of the cable, and this capacity is distributed fairly uniformly along the cable. Owing to this circumstance, all attempts made hitherto to annul or compensate its operation by means of devices situated at the *ends* of the cable, have met with very limited success. Whereas, the ordinary speed of signalling through an Atlantic cable is about eight words or so per minute, it would be quite possible to send 400 words per minute through a line of the same resistance, but destitute of capacity.

The only effective way to annul the retarding effects of a *distributed* capacity is to apply a *distributed* remedy; that is to say, abandoning the idea of compensating it by devices placed at the ends of the cable, means must be sought for applying compensating devices *distributively* along the length of the cable, either at intervals or continuously.

It is well known that the effects of electromagnetic induction are, in a sense, reciprocal to those of capacity. The most familiar modern example is that of the opposite operation of self-induction and of capacity on the phase of an alternate current, the one tending to produce a lag, the other a lead, in the phase of the current relatively to the electromotive force. It is obvious that if electrostatic capacity can be used to correct the effects of electromagnetic induction, conversely it will be possible to use electromagnetic induction to correct the retarding effects of electrostatic capacity.

There are two main modes of action of electromagnetic induction, namely, *mutual induction*, from wire to wire (with or without an iron core intervening, and sometimes called electrodynamic induction), and *self-induction* when the current in a wire reacts inductively on itself. Both are known to be due to the setting-up, by currents, of magnetic fields in their neighbourhood.

There are a very large number of ways in which, theoretically, the end may be obtained of compensating the effect of the distributed capacity by means of distributive electromagnetic induction. It will suffice here to consider two simple cases, and for the sake of simplicity it will be supposed

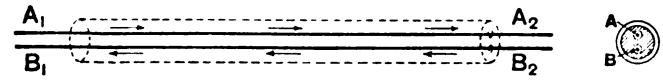

Fig. 1.

that each is applied to the case of a cable containing two insulated wires for the out-going and returning currents. Such a cable may be represented in Fig. 1, where A A is the out-going wire or "line," and B B the incoming wire or return. In the subsequent figures the sheathing will not be specifically indicated.

Case I.—*Use of Self-Induction Devices Distributively.*

In this case a series of self-induction coils of sufficiently high resistance and sufficiently great inductivity are placed across at intervals from the A conductor to the B conductor. In order the better to follow the action it will be convenient

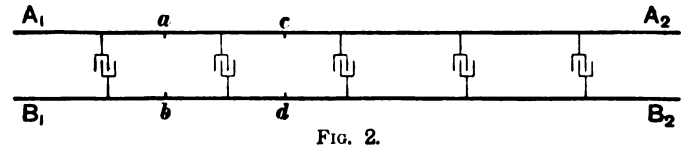

Fig. 2.

to represent the distributed capacity as in Fig. 2. Here the two conductors $A_1 A_2$, $B_1 B_2$, are drawn as though each in itself was devoid of capacity, but that a capacity was given to them in a distributive way by arranging a number of condensers along at intervals, each condenser having one coating joined to the A line, and the other coating joined to the B line.

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Suppose the signalling to take place from the left-hand end, and that a wave of current is being thrown into the circuit at A_1 by a transmitting apparatus joined to $A_1 B_1$. Were there no capacity or inductivity in the line $A_1 A_2$, the wave would travel simply along without retardation. But the presence of capacity changes all this. When the potential at A_1 is rising the potential at some point along the line a would not rise simultaneously, because of the capacity in the intervening part of the conductor. The potential at a cannot rise to its proper value until the condenser between A_1 and a has received its charge. Similarly, the potential at c does not rise as soon as at a, because of the action of the capacity between c and a. Again, when the potential at A_1 is falling, it will not also fall at a or at c simultaneously, because the condensers in between tend to keep up the potential, and take time to empty themselves. Whenever the potential at any part of the line is rising, some of the current tends to flow into the condenser at that part, with the result that the rise of potential in that part is delayed, while the current beyond that part is for the moment smaller than the current that is coming up to the part. Further, when the potential at any part is falling

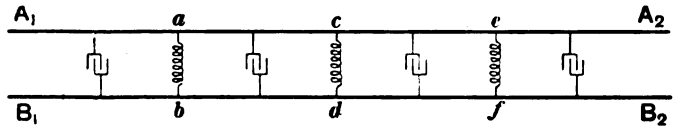

Fig. 3.

there is a tendency for current to flow out of the condenser at that part, and thereby keep up the potential a little later; so that at that moment the current flowing away from the part in question is greater than that flowing towards the part. If nothing is done to compensate this action, the effect would be that virtually all the wave thrown into the cable at A_1 would be taken up in playing into and out of the successive condensers, and so only an insignificant and much-retarded fraction of it would reach the end A_2.

Now suppose that self-induction coils are placed across the cable at the proper intervals, as in Fig. 3. The operation of these coils in compensating the retarding effect of capacity is as follows:—When the potential at a rises, current begins to flow through the self-inductive coil $a\,b$, and this current tends, by the well-known inertia-like action of self-induction, to go on after the applied electromotive force producing it has begun to diminish, or has even stopped or reversed. Hence the current in the self-induction coil $a\,b$ will attain its maximum value at a time after the potential at a has began to fall. It will by that very circumstance, as a consequence

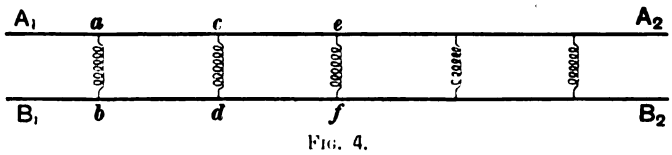

Fig. 4.

of the electromagnetic momentum, tend to make the potential at a fall *sooner* than it otherwise would do. Hence the respective actions of the self-induction coil and of the condenser are of opposite kinds. One tends to cause the changes of potential in the line to occur *later* than they should occur: the other tends to cause the changes of potential to occur sooner than they otherwise would occur. Hence their action tends to compensate one another if applied at the same place. But the capacity of a line or cable is not at one place; it is distributed all along it. Therefore it is essential that the compensating devices should also be placed all along it, at sufficiently frequent intervals. It is well known that Varley employed an inductive shunt *at each end* of a cable; but this is not capable of compensating the capacity, except within, at most, a few score miles of the ends. The coil $a\,b$ (Fig. 3) may be looked upon as compensating the capacity on both sides of it to a certain distance; the coil $c\,d$ as compensating the capacity on both sides of it; and so forth. If all these compensators are properly ranged along the cable, then the total retarding effect of the distributed capacity will be practically annulled. The currents that run in and out of the transmitting end will be greater in quantity than those that are delivered in and out at the distant end; the difference being of course accounted for by the currents that flow across through the compensating coils. It will be seen that by the use of these devices a certain fraction of the currents that are sent in at the transmitting end is, so to speak, used up on the way to pass through the compensating coils and by their action prevent the retardation of the rest of the currents that are flowing down the line. To put the matter tersely, the compensators act as leaks across from the A line to the B line, which by their inductive action sweep out the accumulating charges that would otherwise retard the signals. Some calculations on the magnitude of the currents that must thus flow across in the compensating coils have been made by the author, and some others for him by Dr. Sumpner. From these it appears that taking as a working basis the actual facts about cables as they are, and assuming a twin wire cable having a capacity of $\frac{1}{3}$ microfarad, and a resistance of 10 ohms, for a mile length, also assuming that compensating coils are placed across at every 10 miles, if such coils have a coefficient of self-induction of 100 henries and a resistance of 3,000 ohms

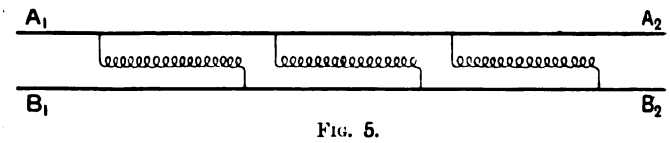

Fig. 5.

each (its time-constant being then about $\frac{3}{100}$ths of a second), the rise and fall of current in each section will, with currents of the ordinary telephonic periodicity, be practically instantaneous in each section during the very small fraction of a second that the impulse lasts; and the value of the current from section to section will be practically determined solely by the shunting action of the successive compensators. Now, as telephonic currents may be shunted down to an extraordinary degree of tenuity, and yet be perceptible, it is evident that there are great possibilities opened out by this method of using the shunted portions of the current to neutralise the retardation.

The cable so constructed of two wires with compensating devices shunted across at intervals of 10, 20, or it may be 500 miles apart, will be represented diagrammatically by Fig. 4. The practical problem then remains how to provide compensators having a sufficiently great time-constant without their constituting unwieldly enlargements of the cable. This is a very simple matter of construction. The author has tried several species of devices, some of them resembling elongated "hedgehog" transformers made very long and thin, and

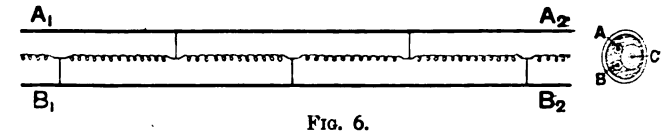

Fig. 6.

wound with one coil only of fine wire; others consisting of "shell" transformers elongated into a very long, narrow loop: others again consisting of simple iron wire, straight or looped, or of wire over-wound with a layer of iron wire. The self-induction, for example, of a one-millimetre iron wire, over-wound with a layer of iron wire three millimetres deep, is roughly about 0·1 henry per kilometre; and its resistance is 144 ohms. One point in favour of the use of loaded straight wires as self-induction devices is the circumstance that the compensator need not join two adjacent points in the two conductors within the cable, but may lie across as in Fig. 5. This construction, which is specially suitable for cables of moderate length, resolves itself into a three-wire cable, of which one wire is loaded in some way to give it self-induction and resistance, and is connected at intervals alternately to the other two, as in Fig. 6.

As stated above, however, not only by self-induction but by mutual induction, the retarding effects of capacity may be neutralised.

(To be continued.)

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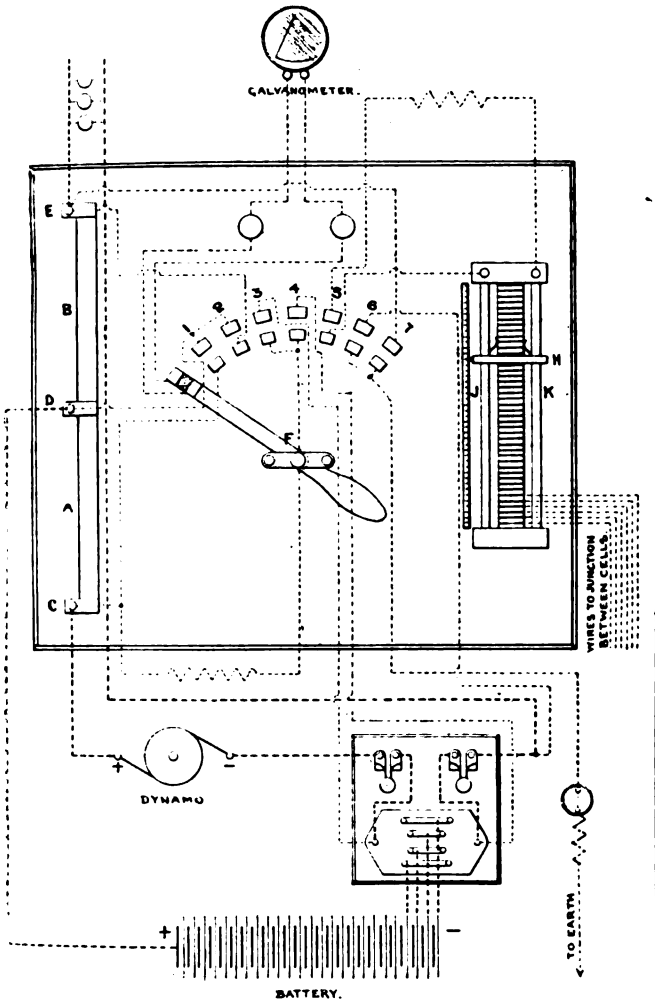
APPARATUS FOR THE COMPLETE TESTING OF A BATTERY OF SECONDARY CELLS.

The object of this apparatus is to provide an accurate and convenient means of making complete and rapid electrical tests of a battery of secondary cells such as is used in lighting a private house, or in central stations for electric supply. Only one instrument, the Holden-D'Arsonval galvanometer with a 10-turn coil, is used for all the tests, and no other ammeter, voltmeter, or cell-tester is required.

The apparatus (the internal arrangement and connections of which are shown in the accompanying figure) consists of a



case with glazed front containing the switches and resistances, which can be placed wherever convenient, either near to or some way away from the batteries, without in the least affecting its accuracy or efficiency, and a Holden-D'Arsonval galvanometer, as already described, with lamp and scale (see *The Electrician*, Vol XXXI., p. 257). The case will be seen to contain on its left-hand side a strip of platinoid A B, of suitable proportions for the maximum charging and discharging current; in the centre a double-pole switch, having seven positions; and on the right an individual cell-tester switch, which enables each cell in the battery to be tested for E.M.F. separately. The diagram shows the connections of the various portions of the apparatus, and the letters on this diagram correspond to those on the diagram of the actual apparatus. Position 1 of the switch measures the current leaving the dynamo in the following manner:—

The + pole of the dynamo is connected to C, and the + pole of the battery to D, the + main to the lamp being connected to E. Now, the double-pole switch when in position 1 connects the galvanometer wires direct to the points C and D, and, therefore, the galvanometer measures the fall of potential between the points C and D due to the charging current to which the fall of potential is proportional. This gives, therefore, a measurement of the current leaving the dynamo. In position 2 of the switch the galvanometer terminals are connected to D and E, and, therefore, the galvanometer measures the fall of potential between these points due to the current flowing to the lamps, otherwise the discharging current in the mains. In position 3 the terminals of the galvanometer are connected through a resistance of 50,000 ohms (for a 100-volt circuit) to the terminals of the dynamo, and thus a measurement is obtained of the charging E.M.F. In position 4 the galvanometer is connected in a precisely similar manner to the + and − lamp mains direct, so that the discharging E.M.F. is shown. In the fifth position the switch is connected through a resistance of 1,000 ohms to the bars J and K, which are in their turn connected to two springs underneath the sliding-piece H. Now, each of the rings of the switch being connected to the joint between one cell and the next one in the battery, it is obvious that in each position of the switch one cell only will be in circuit with the galvanometer. By means of a pointer attached to the sliding-piece H and the fixed scale, the instrument can be set with ease and certainty to measure any cell in the battery. The sixth position enables the insulation resistance of the + main to be measured by joining the + main to one terminal of the galvanometer, whilst the other is put to earth through a resistance and a fuse; and, finally, in the seventh position of the switch a direct measurement of the insulation resistance of the − main is obtained in a similar way. A suitable arrangement of scale and light for this apparatus is as follows:—The galvanometer is placed some 8ft. or 10ft. away from the scale, which should be about 10ft. long, and should have the various graduations in volts and amperes above and below the centre line. Immediately above and behind the centre of the scale is placed the lamp, the light from which shines through a slit $\frac{1}{4}$in. wide and about 3in. long—through a 2$\frac{1}{2}$in. or 3in. lens—to the galvanometer mirror, whence it is reflected back on to the scale, where it appears as a broad, vertical band of light. This band, if there is a line or wire across the lens, will be divided by a dark line serving as an index. The scale can be placed at a considerable height above the floor of the battery, or testing-room, and may conveniently be fastened to one of the walls. The galvanometer may be placed on a small bracket on the opposite wall, and the remainder of the apparatus placed in any available position. By this means the testing device can be made to monopolise but a small amount of useful space, and the floor of the room is left available for any other purpose. This convenient testing set is manufactured by Mr. J. Pitkin and supplied by Messrs. Drake and Gorham, agents for Major Holden's electrical instruments.

Rival Forms of the Clark Cell.—Dr. K. Kahle, of the Imperial Physico-Technical Institute at Charlottenburg, gives some further results of his comparative tests of Clark cells in the current number of the *Zeitschrift für Instrumentenkunde*. In his opinion the H form, as first suggested by Lord Rayleigh and subsequently modified by himself, is the best for permanency and facility of transport and reproduction. The Board of Trade form, where both the electrodes enter through the stopper, shows irregularities sometimes amounting to 1 per cent., which he attributes to want of saturation of the zinc sulphate solution at some points of the surface of the zinc, and also to the passage of small particles of zinc through the paste into the mercury. The substitution of cadmium for zinc he regards as a promising innovation, but with certain precautions there is no reason why the Clark standard cell should not supersede the silver voltameter as a calibrating instrument for galvanometers and other purposes. Commercial zinc does not contain any positive metals capable of sensibly affecting the electromotive force of the cell; but more negative substances, like arsenic, are apt to give rise to bubbles of hydrogen, which introduce a high resistance. The zinc should be well amalgamated, and the zinc sulphate solution perfectly neutral. Allowing for temperature cofficient, which has been accurately ascertained, the majority of the instruments constructed at Charlottenburg have been found reliable to within 1 part in 10,000.

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Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny

Editorial, Publishing, and Printing Offices:

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.

Telephone No. 2714. Telegrams: "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "Coutts and Co."

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All letters intended for insertion in "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as evidence of good faith. No notice whatever will be taken of anonymous communications.*

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AVERAGES.

Trustworthy statistics are the foundation of many a successful engineering enterprise, and in the preparation of schemes for the supply of towns with electric light, the average number of lamps per house or per inhabitant, the average number of hours of lighting per day, the average length of mains, and a dozen other numerical expressions of great simplicity, but of grave importance, are freely quoted. Our New York contemporary, the *Electrical World*, has, however run foul of the engineering practice of striking an average. "Nothing is more dangerous," it says, "from a business point of view than dependence on the average; the average cost per horse-power of water power, steam or electrical machinery, and the numerous other tables of approximate information are often worse than useless, as an estimate based on them alone must in most cases be either too high and thus cause the loss of a contract, or, what is worse, will be too low and cause a direct financial loss." This is all very well; but there are averages *and* averages, and everything depends on taking the correct one.

The word average is used loosely to cover several distinct statistical processes, whereby a single numerical expression represents a generalisation from two or more data. If the data may, from a certain point of view, be considered to be

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essentially similar, but to differ among themselves by accidental quantities, the process of striking an average tends to eliminate these accidental quantities, the degree of elimination being proportional to the square root of the number of data. But when the data cannot be regarded as essentially similar, nor the differences as accidental, an average is often both useless and misleading. A man proposing to manufacture glow lamps, and wishing to find what candle is most commonly used, might learn that a certain supply company has 25,000 8-c.p. lamps and 12,500 16-c.p. lamps on its mains. To deduce from this that the average candle-power is 10·6 would be absurd, but such averages are often used. To describe the capacity of a central station by its average output is perfectly useless. The ratio of this average to the maximum output gives the load factor, a most useful quantity, but one that tells nothing whatever about the size of the station. The mean steam pressure of an indicator diagram cannot be found from a few measurements, unless SIMPSON's rule or some conditions as to the selection of these measurements be observed. The practice of applying false reasoning to true averages is, perhaps, even more common than that of obtaining misleading averages. It has been said, for instance, that as the average number of people who die in bed in the course of a year so largely exceeds the average number who are killed in railway accidents, a sleeping car is, therefore, incomparably more safe than a bedroom. Statistics are generally quite unpresentable to the public unless the data upon which they are based are reduced to averages, and where, as in prospectus-writing, companies' and other reports, and similar documents, it is sometimes desired to put forward certain views in the guise of statistics, averages are freely used and too often abused.

Dr. GUY, writing on medical statistics, observed that "averages are numerical expressions of probabilities; extreme values are expressions of possibilities." The condition of things expressed by the average may never occur, and there may be good reasons for its never occurring. The idea of an average includes the idea of deviation from the average value, and the full discussion of the mean deviation, and of the probable deviation, or error, as it is sometimes called, and of the number of decimal places to which the expression of the average should be carried, are matters of considerable importance, but seldom receive much attention. An average is a particular kind of mean, the arithmetic mean. Besides this, we have geometric mean, the complicated and pretentious "method of least squares," and then again there is the puzzling "square root of the mean square," *et hoc genus omne*. We have long ago pointed out that the plain and simple arithmetical average of 10 alternating amperes would, if commutated into a direct current, be considerably different from 10 simple continuous amperes; whereby—had the Board of Trade been unwary in its choice of an "average"—an unscrupulous person might have made unlimited profit by merely grinding round a small commutator. There is besides all these purely arithmetical averages the system of weighted averages. These had best be left to astronomers, physicists and other men of irreproachable rectitude, for the application of the weights must be a matter of judgment, and would be a dangerous weapon in the hands of a company promoter. For ordinary purposes the simple average, used rationally, based on data which are properly comparable, sufficiently numerous, and which do not differ too much among themselves, is the true average. The true average, in any case, is that one whose substitution for the variable would produce the same numerical result, and there can be nothing approximate, risky, or erroneous in taking the one of these in place of the other.

THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 421.)

The effect of flashing is threefold, as already explained. It alters the emissivity, the resistance and the thickness of the filament. It diminishes the resistance, and, usually, the emissivity, and increases the thickness. The effect of increasing the thickness is opposite to that of diminishing the emissivity. That is to say, increase of thickness means increase of candle-power and decrease of emissivity means decrease of candle-power. The reduction in resistance and the increase in thickness continue to proceed as long as the process is going on. The emissivity, however, is changed almost entirely within the first few seconds, after which it remains practically constant.

What the lamp-maker wants to know is what sized filament he must take in order to produce such and such a lamp. If he is making unflashed filaments the matter is very simple, and the dimensions are readily calculated. If, on the contrary, he wishes to flash his filaments, the conditions are complicated by the three separate effects just mentioned.

A formula for calculating diameters for flashed filaments, on the same lines as for unflashed ones, might here be given. Owing, however, to the necessity for the introduction of constants, on account of the difference in specific resistance of the filaments and the deposited carbon, it becomes too cumbrous for practical use, and is, therefore, omitted. Instead of using the formula, a number of different cases can be worked out separately, and the results plotted out in curves, from which any other sizes can be easily and quickly obtained. Such curves are shown in Figs. 19 and 20.

Having obtained the curves, they are useful in enabling us to do several things at a glance. For instance, a particular lamp is to be made and its current must be so-and-so. The curves show at once what diameters of filament may be taken, and how much they must be flashed in order to produce the result. If it is desired to give the filaments a definite thickness of deposit, there is one diameter alone which will answer the purpose. Suppose that it is desired to give a coating 0·3 mil thick. It takes 60 seconds to do this. Take the case of a 100-volt, 16-c.p., 0·64-ampere lamp. We find on the 60 seconds curve (Fig. 19), that we must take a filament 5·3 mils diameter to give this current. During the process of flashing it will become thickened to 5·9 mils, a fact which must be remembered in estimating its length. The length to be taken is given as before by the formula $l = b\frac{\text{c.p.}}{d}$, d being the finished diameter, the value of b in the case of the flashed surface being 2·8 (*i.e.*, the constant for the unflashed surface $\times \frac{14}{10}$, the ratio of the emissivities)

Therefore $$l = 2{\cdot}8 \times \frac{16}{5{\cdot}9} = 7{\cdot}6\text{in.}$$

7·6in. of 5·3 mils diameter filament must then be flashed for 60 seconds, and it will then be the right resistance and surface.

This, therefore, shows another way by which filaments may be flashed to the required resistance. No instruments are needed except a watch to show the time of flashing. Start with the proper size of filament shown by the curve, and flash it for the required length of time, and it is brought to the required resistance. Such a method, however, would not work well in practice owing to the difficulty of exactly reproducing to conditions each time. If, however, the right size of filaments, as shown by the curve, are taken and flashed to their proper resistance hot, the time of flashing will be 60 seconds on the average.

It will be seen by examining the curves that there is a wide range of possible sizes for the filament, according to the

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amount of flashing it receives. For the same lamp taking 0·64 ampere, a filament 3·7 mils in diameter flashed for two minutes gives the required result, or one of 7·65 mils flashed for only ten seconds will do equally well.

It has, however, been pointed out that thirty seconds is about as long a time as can be allowed for flashing in practice. By taking the sizes given by the thirty-seconds curve we get always, for any current, the diameter which will take thirty seconds to flash to its required resistance.

On examining the curves, one thing that immediately attracts attention is that the curves for the flashed filaments D, E, F, G, H, J, cross the curve for the unflashed ones A, at some point. This is on account of the variation in the equivalent specific resistance of the flashed filaments.

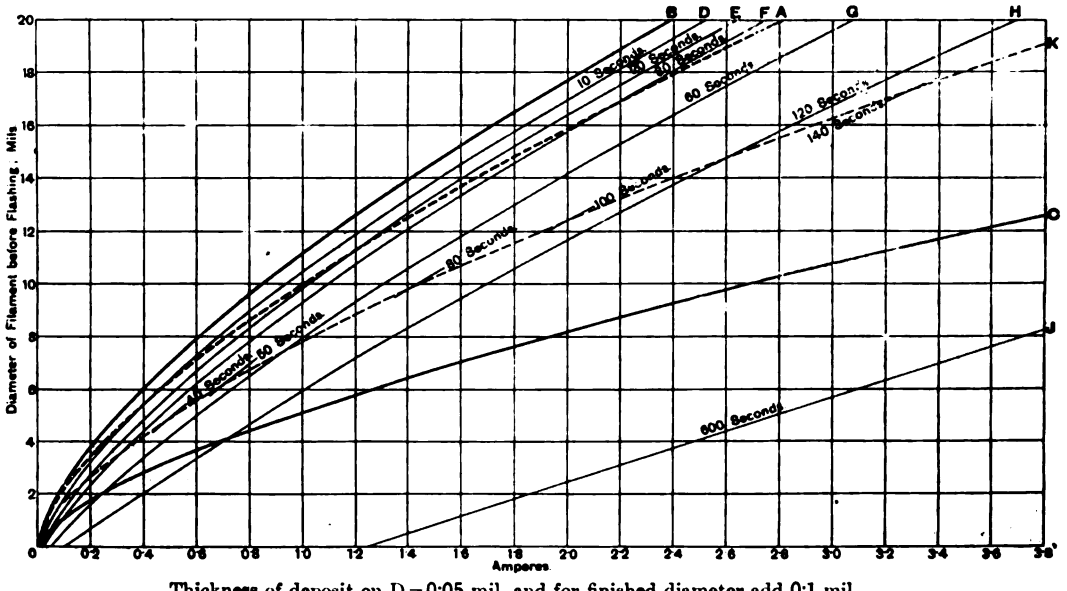
The topmost heavy curve B shows what the result would be if the filaments could be flashed so as to give the less emissivity of the deposited carbon, but without changing the resistance. In other words, it is the curve for a carbon of the specific resistance of the unflashed, but with the emissivity of the deposited variety. It is introduced in order to show the limit of diameter for any current beyond which it is impossible to go under any conditions with these two qualities of carbon. In the other direction the limit of the diameter is zero; that is to say, the amyloid filament vanishes altogether, deposited carbon alone remaining.

6 mils being the diameter of a solid filament of deposited carbon alone. The lower heavy curve C gives the values for such material.

In order to make the matter as clear as possible the second sheet of curves (Fig. 20) is given, showing the final or flashed diameters. It will be noticed that all the sizes lie between the limits of the heavy curves B and C. It is, however, the diameters of the filaments before flashing that the lamp-maker requires in the first instance.

Looking at the curves (Fig. 20) we see for any current within what limits the final diameter of the filament for that current must lie. Thus, for two amperes the final diameter will lie between 8·2 and 17·7 mils. Theoretically, any diameter between these limits may be made to do for two amperes, according to the length of time of flashing, or no flashing at all if the filament be 15·9 mils, as shown by the dotted curve A.

In actual practice the limits are somewhat more restricted, on account of the difficulty of making or handling very thin filaments or of flashing properly in less time than 10 seconds. The practical limits for this current may, however, be considered as 10 mils and 17 mils finished diameter, still a very wide range, according to whether the flashing be done for 10 seconds or up to five or six minutes. This means that the filament before flashing will have a range of from 4 or 5 mils to 17 mils


B D E F A G H K
10 Seconds
30 Seconds
60 Seconds
120 Seconds
140 Seconds
100 Seconds
80 Seconds
40 Seconds
50 Seconds
800 Seconds
C
J
Diameter of Filament before Flashing. Mils
Amperes
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38
0 2 4 6 8 10 12 14 16 18 20

Thickness of deposit on D = 0·05 mil, and for finished diameter add 0·1 mil.
" " E = 0·10 " " " " " 0·2 "
" " F = 0·15 " " " " " 0·3 "
" " G = 0·30 " " " " " 0·6 "
" " H = 0·60 " " " " " 1·2 "
" " J = 3·00 " " " " " 6·0 "

Curve A gives diameters for currents up to 3 amperes for the usual quality of unflashed carbon.

FIG. 19.—Curves showing Relation between Current and Diameter of Filaments for Different Durations of the Flashing Process. (The diameters represent the measurement of the filaments *before* being flashed.)

Thus the diameter selected for a 1·25-ampere filament at the temperature of 4 watts per candle power may be anything from 12·9 mils down to nothing, according to the time of flashing. If unflashed carbon is used the diameter, as shown by the dotted curve A, will be 11·6 mils; if flashed for 10 seconds it will be 12·3 mils; for 20 seconds, 11·7 mils; for 30 seconds, 11·15 mils; for one minute, 9·7 mils; for two minutes, 7·5 mils. The limit of zero diameter is reached (supposing such a thing possible) at the ten-minutes' curve. It must be remembered that the diameters shown by the curves (Fig. 19) are the diameters of the filaments before flashing, and that the actual finished diameters are greater according to the length of time they are flashed by one-tenth of a mil for every 10 seconds. In the limit when the diameter of the unflashed carbon becomes zero the actual diameter is 0 + 6 mils, 6 mils being the increase in diameter produced in ten minutes. In other words, the filament is now entirely of deposited carbon, and 6 mils in diameter. Speaking, then, of the final or flashed diameter, the limits for 1·25 amperes are 12·9 mils and 6 mils, in diameter. If the time of flashing is to be restricted to 30 seconds then 16·05 mils will be the finished diameter and 15·75 the diameter before flashing.

The fact that flashing a filament may *reduce* as well as increase the current strength necessary to raise it to a given temperature, is one which the author believes to be not generally realised. Looking at the curves for finished diameters, it is seen that an unflashed filament of 14 mils diameter takes about 1·66 amperes. A filament of this diameter which has been flashed for ten seconds takes only 1·49 ampere. One which has been flashed for twenty seconds takes 1·58 ampere, while one flashed for thirty seconds takes 1·66 ampere, the same as the unflashed one of that diameter. If flashed for a longer time than thirty seconds it takes more current than the unflashed one.

When the diameter and current are the same for unflashed and flashed, as in this case for fourteen mils and thirty seconds, the lengths of the filament to produce the same volts and candle-power will be in the proportion of ten

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to fourteen, the length of the flashed filament being greater in inverse proportion to the alteration in emissivity.

Looking at the curves showing the diameters *before* flashing we see that an unflashed filament of 16·8 mils diameter takes 2·18 amperes. If this same filament be flashed for ten seconds, it takes only 1·97 ampere, if it be flashed for twenty seconds it takes 2·07 amperes, and if for thirty seconds it takes 2·18 amperes, the same as it did before being flashed. Its diameter is, of course, increased by 0·3 mil and is 17·1 mils.

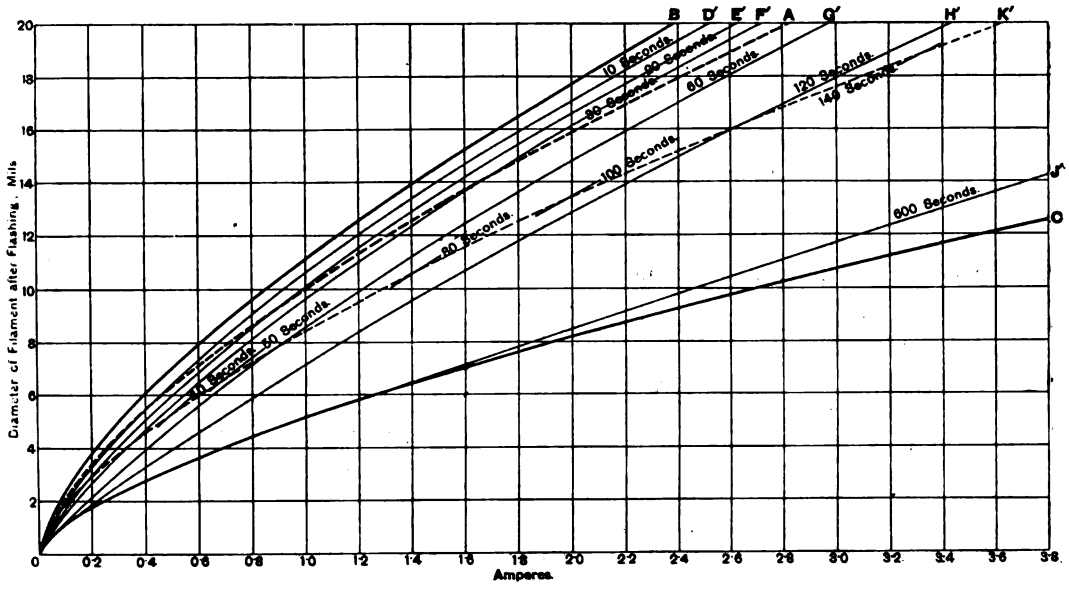
Here, again, let there be no misunderstanding about efficiency. The filament, flashed for a short time and which takes less current and fewer volts than it did before flashing to maintain it at a certain temperature, is no more efficient than before flashing. The power required to produce the temperature is less. In precisely the same proportion is the candle-power also less.

When filaments are flashed to a certain resistance measured cold, it has already been pointed out, that owing to the widely different temperature coefficients of the filament and the deposited carbon, it is essential that the ratio of the two amounts of these carbons present in the filament be known. In a factory where the cold measurement is adopted it should be a rule always to flash the filaments so that there is a fixed ratio between the sectional area of the filament and that of the deposit, that is to say, between their resistances.

It has been mentioned that the general formula for diameters of flashed filaments is too cumbrous for ordinary use, owing to the difference in the specific resistance of the two kinds of carbon having to be taken into consideration. When, however, there is a fixed ratio between the quantities of the two kinds of carbon in the filament, the formula becomes of the simple form, $d = a\,c^{\frac{2}{3}}$, where d is the diameter of the filament, c the current, and a is a constant, the value of which depends on the specific resistance of the filaments, the emissivity, the units employed, and the temperature at which the filaments are to be run. In order, then, to find the right diameters to use, so that there shall always be a fixed ratio between the resistance hot and the resistance cold, it is only necessary to find the value of the constant a for whatever ratio is required, and the formula gives the required result.

If we arrange matters so that the cold resistance is for all diameters twice the hot resistance, then, having determined the corresponding value of a, we shall find that the curves K and K′ (Figs. 19 and 20) give the diameters before and after flashing. Supposing, then, that the filaments are flashed until the resistance measured cold is brought down to the value of twice the required resistance hot, we can at once find the diameter for any current from these curves, and we can also see the time which will be occupied in the flashing by the crossing of the curve with the time curves D, E, F, G, &c.

In many lamp factories, the sizes of filaments and the amount of flashing they receive are regulated entirely by guess and trial methods. Such methods, no doubt, answer the purpose in the end just as well as a calculation by a formula, or information obtained from a curve. But by a proper understanding of the effects produced by alterations in the diameter of the filament or the time or conditions of the flashing, the required results can be much more certainly and quickly obtained. Of course, it is impossible to get lamps all *exactly* right by any method. There are too many causes at work to upset the calculations, too many variable conditions to be simultaneously taken into account. Nine out of ten of the things to be considered may be right, the tenth one being wrong throws the combined result wrong. It is, however, only by taking everything into consideration that good results can be expected.



D′ has been flashed for 10 secs., and is 0·1 mil thicker than before flashing.
E′ " " " 20 " " 0·2 " " " "
F′ " " " 30 " " 0·3 " " " "
G′ " " " 60 " " 0·6 " " " "
H′ " " " 120 " " 1·2 " " " "
J′ " " " 600 " " 6·0 " " " "

Fig. 20.—Curves showing Relation between Current and Diameter of Filaments for Different Durations of the Flashing Process. (The diameters represent the measurement of the filaments *after* being flashed. A, B, and C are the same curves as on Fig. 19.)

A good instance of the happy-go-lucky methods sometimes used was seen a few years ago by the author in a factory, where the filaments were flashed in an apparatus, using an automatic cut-off, which stopped the current when it attained a certain value. This cut-out was a very crude affair, and was not at all particular as to when it went off. The flashing globes were allowed to get so black that the operator could not possibly gauge the temperature of the filament, and the consequence was that the cut-off would "act" just when the operator chose to turn the current up sufficiently. After this process the filaments were "selected" by measuring their resistance cold, a range of about twenty per cent. being allowed. The result was that three-fourths of the filaments were rejected. Of those that came within the limits of the resistance cold, perhaps one-third would be of the right resistance hot, which was always assumed to be half the cold resistance. The proportion of lamps of the proper voltage was, of course, extremely small, while the percentage of filaments which became lamps of the right voltage was microscopical.

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The factory above alluded to was, luckily, situated in a country where very badly-matched lamps could be sold as of the same voltage. Any one who visits the Continent at the present time will, with a very slight observation on the lamps to be seen in use, be convinced that kindred methods must still be in use in a good many factories. The unfortunate part of it is that this country, before another year is over, is likely to be flooded with these foreign badly-matched lamps, which people will buy on account of their cheapness.

DYNAMO SHIELDING.

BY W. H. M. CHRISTIE (ASTRONOMER ROYAL).

The proposed establishment of a system of electric lighting at the Royal Observatory, Greenwich, made it necessary to consider the possible disturbing effect of a dynamo on the magnets of the Magnetic Observatory, and how far the influence thereof could be diminished by any system of shielding.

Messrs. Johnson and Phillips, of Old Charlton, having been selected to supply the electric light installation, they very kindly undertook to give facilities for carrying out, at their works, such experiments as were considered necessary, and it is due to the valuable assistance so given that a satisfactory protection of the magnets has been arranged.

From the general interest felt in the subject of shielding, it may be interesting to give here an account of the experiments made. Protecting shields of various sizes having been prepared by Messrs. Johnson and Phillips, the effect of different combinations of shields was tried, employing in all cases the dynamo actually constructed for use at the Royal Observatory, which is to give 2 kilowatts with 130 volts. The dynamo in the experiments was, for convenience, driven as a motor by a current of 130 volts, and the shunt-wound single-horseshoe field-magnet was excited with 80 volts, a resistance being interposed in the shunt to reduce the intensity of the magnetic field.

The disturbing effect of the dynamo when unshielded was in the first instance measured. For this the dynamo was arranged with poles in an easterly and westerly direction (magnetic), a delicately suspended magnetic needle, that of a Kew unifilar, insuring accuracy of measure, being mounted at two different distances west (magnetic) of the dynamo. In this disposition of the apparatus (with the needle east or west of the dynamo) the maximum disturbing effect at a given distance is obtained. Measures were made on March 9th last as follows:—

Distance of magnetic needle west of dynamo.	Deflection of needle, dynamo not shielded.
Feet.	
20	168′ 40″
40	23′ 40″

The reading of the suspended needle was usually taken in reversed positions of the dynamo poles, the angular deflection given being the half difference of the extreme readings.

Practically, the disturbing effect of one magnet on another will vary (the relative positions being the same) as the inverse cube of the distance, provided that the distance is large as compared with the size of the magnets. On this understanding, the observed angles being small, the deflection measured at 40ft. should be one-eighth part of that measured at 20ft., or should be 21′ 5″; the observed value is 23′ 40″, showing that for the dynamo the ordinary law sensibly applies.

Three shields of different sizes, made of ¼in. iron plate, each one being in the form of an arch (with open sides) were employed; they were placed over the dynamo with their open sides in the direction of the dynamo axis, that is north and south, and two or more shields could be in position together, there being a small air space between each. Side pieces of similar plate iron were also prepared, which could be added at pleasure on either side of the arch.

The following measures (also on March 9th) were made, the magnetic needle being distant from the dynamo 40ft. west, and the poles of the dynamo in an easterly and westerly direction as before, which was indeed the position of the dynamo poles throughout the experiments:—

Arrangement of protecting shield.	Deflection of needle, dynamo shielded.	
	Shield without sides.	With sides.
Large shield only.....	9′ 30″*	8′ 16″
Small shield only	6′ 46″	5′ 22″
Small and medium shields.....	5′ 32″*	—
All three shields	3′ 42″	3′ 15″

The measures marked thus * were made in one position only of dynamo poles.

The results in the first column indicate that the shielding effect is generally greater the nearer the shield is to the dynamo. The best effect is produced by use of the three shields with side pieces, the deflection being thereby reduced from 23′ 40″ (the value with dynamo unshielded, at 40ft.) to 3′ 15″, or to a one-seventh part.

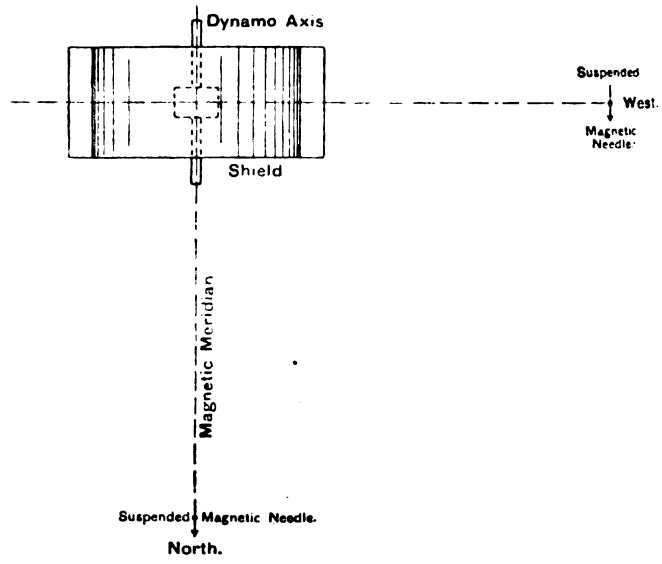

FIG. 1.—Plan showing Arrangement of the Apparatus.

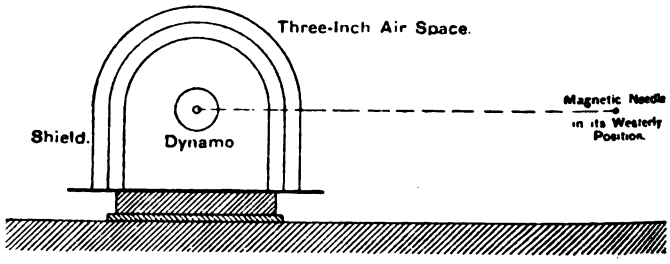

FIG. 2.—Section in an East and West Direction through Shield and Dynamo.

The three shields were now attached all to one base plate, thus forming a triple shield, entirely closed on one side, but with a necessary partial opening on the other, the dynamo being in the centre of the inner shield. The horizontal diameter of each of the three shields is 28in., 34in., and 40in. respectively, and their height from base plate 31in., 34in., and 37in. respectively, the air space between adjacent shields being thus about 3in.

With the triple shield as thus prepared, further experiments on May 31st were made:—

Distance of magnetic needle from dynamo.	Whether needle was west or north of dynamo.	Deflection of needle.	
		Dynamo shielded by triple shield.	Dynamo not shielded.
Feet.			
20	West.	24′ 58·5″	—
40	West.	2′ 45·2″	19′ 38·0″
60	West.	0′ 54·4″	—
40	North.	1′ 1·8″	9′ 20·8′

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By the already mentioned law the deflection at 40ft. should be one-eighth of that at 20ft., or one-eighth of 24′ 58·5″ = 3′ 7·3″ The observed value is 2′ 45·2″ And the deflection at 60ft. should be $\frac{1}{27}$th part of that at 20ft., or 55·5″, the observed value being 54·4″. Again, the deflection at a given distance, with needle north, should be approximately one-half of that with needle west. Half of 2′ 45·2″ is 1′ 22·6″, the observed value being 1′ 1·8″, and half of 19′ 38·0″ is 9′ 49·0″, the observed value being 9′ 20·8″ On the whole, the observed results follow satisfactorily the ordinary law.

So much for consistency of the results. As regards the other important point, the influence of the shield in diminishing the disturbing effect of the dynamo, we have now the following results :—

Day.	Magnetic needle west or north of dynamo.	Deflection of needle.		
		Dynamo not shielded.	Dynamo shielded by triple shield.	Reduced by shielding to
March 9 ...	West	23′ 40·0″	3′ 15·0″	$\frac{1}{7}$th part
May 31 ...	West	19′ 38·0″	2′ 45·2″	$\frac{1}{7}$th „
„	North	9′ 20·8″	1′ 1·8″	$\frac{1}{9}$th „

Distance of magnetic needle from dynamo = 40ft.

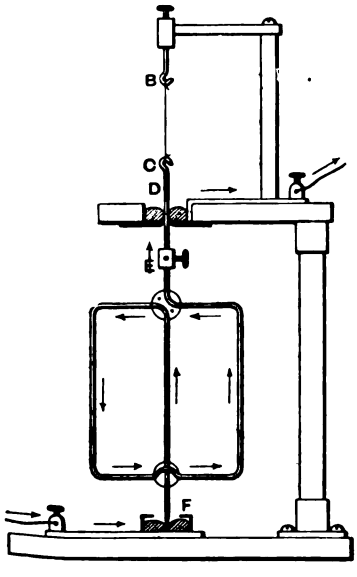
These results were arrived at with essentially the same condition of shield, the only difference being that on March 9th, the parts of the shield were not attached, whilst on May 31st the experiments were made with the completed shield.

The reduction of the disturbing effect of the dynamo thus produced is eminently satisfactory. At the distance at which it is proposed to place the dynamo from the magnets at the Royal Observatory the influence of the dynamo (when shielded) on the declination magnet would be reduced to about half a second of arc, and to a correspondingly insignificant amount also for the horizontal force-magnet.

The experiments were carried out by Messrs. Ellis and Nash, of the Royal Observatory, with the co-operation of Messrs. Johnson and Phillips.

A NOVEL ARRANGEMENT FOR AMPERE'S TABLE.

At the annual exhibition of the Société Française de Physique M. Nodot exhibited a novel arrangement of Ampère's table, in which, owing to the very low friction of the moving parts, the action of the magnetic field of the earth and of magnets and currents upon conductors carrying currents, can be shown without the use of any very considerably large forces. The apparatus is represented by the accompanying figure, in which the movable conductor, which has to turn on a vertical axis, is suspended from a fixed hook, B, by means of a silk thread, BC. The lower end of this thread is fastened to a hook in a platinum wire, D, which passes through a small circular hole in a disc of mica with sufficient clearance to prevent friction due to the rotation of the platinum spindle. This mica disc forms the bottom of a mercury cup, as shown in the figure; and the contact of the mercury with the platinum enables the current to pass from the movable conductor. The lower end of the movable conducting frame dips into a second mercury cup, F, in the base of the instrument, by which means the current can be conveyed into the frame. By means of a coupling screw, E, it is possible to disconnect the conducting frame from the suspending wire and thread, and to substitute any other shape of frame that may be desired. It will be seen that, by means of the arrangement described, there will be but a very small amount of friction at the pivots, while the torsion of the silk thread will oppose only a feeble resistance to rotation. The capillarity of the mercury prevents it from creeping through the clearance space between the edge of the circular hole in the mica and the platinum spindle, for mercury does not wet or amalgamate with platinum. It seems not improbable that a delicate adjustment of a suspended coil, such as this one of M. Nodot's, might be useful in galvanometer construction.



THE PRACTICAL MEASUREMENT OF ALTERNATING ELECTRIC CURRENTS.

BY PROF. J. A. FLEMING, F.R.S.*

1.—The Measurement of Alternating Current Strength.

The subject on which I have undertaken to speak in this and three succeeding lectures is the practical measurement of alternating electric currents. The limits of time at our disposal will not permit me to deal with the question of electric measurements in general, far less to discuss the elementary principles on which all such measurements depend. I shall take it for granted that you are, at any rate, familiar with the fundamental facts concerning the production of electric currents, and most, if not all of you, familiar with the processes and instruments used in the measurement of continuous or unvarying currents.

The measurement of alternating or periodic currents involves processes and ideas which are somewhat more difficult to master than the simple conceptions which are sufficient to guide us in dealing with unvarying currents. It is towards the elucidation of these special difficulties that these lectures will be directed; and, keeping in view the special requirements of practical engineers dealing with alternating currents, I shall address myself entirely to the practical question of measurement, leaving out of account altogether theoretical matters. The practical measurement of alternating currents is a very important subject, because probably by far the larger portion of the electric lighting of the world is now conducted with alternating currents, and some of the largest schemes of transmission of power that are in process of development or already completed, are being carried out by means of alternating currents.

Our first duty will be to begin with some familiar definitions which will make clear the meaning of the terms to be employed. When a conductor is traversed by an electric current we know that certain physical effects are produced. We know nothing about the real nature of an electric current. All that we can do is to measure the degree or amount of the physical effects it produces. Two of these effects are at once evident on very simple investigation, namely, that the current heats the conductor and produces around it a magnetic field. The moment we begin to investigate these effects we find that the electric current may be either in a variable state in which progressive changes are taking place in the effects produced by that current, or it may be a steady or unvarying condition in which the effects remain constant; or it may give evidence of being periodic in its nature, that is to say, the electric current may vary in strength and in direction in a periodic manner. When any cycle of operations takes place in such a way that any given effect runs through a series of changes, we speak of the periodic time of that effect, meaning by that term the time in which the whole cycle of operations is completed. Also we speak of the frequency of the change, meaning by that term the number of cycles completed in a second. A familiar illustration of the use of these terms may be drawn from music. In the case of a musical sound, the string, or the air in the pipe runs through a certain cycle of

* Abstract of Cantor Lecture delivered before the Society of Arts, January, 1893.

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movement, and the periodic time of the note is the time of completion of one complete vibration of the string or of the particles of the air; the frequency is the number of complete vibrations per second. The middle C of the piano has, or may have, a frequency of 256, the octave below that 128, the octave below that 64. In the case of electric currents which are periodic, the strength of the electric current is changing from instant to instant, and it is periodically reversed in direction. Applying the above terms, we speak of the frequency of the current, meaning the number of complete cycles in a second. For instance, the alternating current supplied from Deptford has a frequency of about 84, which corresponds to the lower F on the bass clef. The currents employed in the electric lighting of Rome are about an octave lower, namely, 40 in frequency.

You may picture to yourselves the difference between a continuous and an alternating current as similar to the difference between a non-tidal and a tidal river. In the case of a non-tidal river the waters flow on always in one direction—down the river; but in the case of a tidal river, such as the Thames at London Bridge, the direction of the flow of the water is periodically reversed. When we are dealing with periodic currents, or periodic E.M.F.'s, it is very convenient to represent these by means of current curves, or E.M.F. curves. To do this we take a horizontal line to represent the periodic time of the current, and dividing this line into a number of small equal parts, we erect perpendiculars at each point, proportional to the strength of the current, or to the E.M.F. at that instant. Joining the tops of these lines by a curve we have an E.M.F. or current curve. We then may speak of the instantaneous value of the current or E.M.F., meaning thereby the value it has at any instant; or we may speak of the mean value of the current or E.M.F., meaning thereby the average value which it has during the period. It is also necessary to consider another, a rather more complicated kind of average, which is called the square root of the mean square value. This is obtained by taking the mean of the squares of all the instantaneous values taken at the equidistant intervals during the period, and then taking the square root of this mean value. To avoid constant repetition of this cumbersome phrase, the square root of the mean of the squares of the equidistant values during the period, we shall call it shortly $\sqrt{\text{mean-square}}$ value of the current or E.M.F.

Presently we shall see why it is that certain instruments give us this $\sqrt{\text{mean-square}}$ value. It is important, sometimes, to be able to draw these current curves for any alternating current, and this has been done by many observers, notably by Duncan, Ryan, and Hopkinson.

In Fig. 1 we have a diagram of an apparatus used for this purpose by Dr. Hopkinson. On the shaft of an alternator is placed an ebonite disc, having at one point on its circumference a narrow feather of brass laid in. As the ebonite disc is carried round by the machine, the brass edge is made to complete the circuit between two metallic brushes, which press against the ebonite disc, and the instant when this occurs can be determined by varying the position of the brushes. By connecting an electrometer with these brushes in the manner shown in Fig. 2, the electrometer gives us the measure by its deflection of the instantaneous value of the E.M.F force of the machine at that one particular instant. By shifting the position of the brushes we can measure the E.M.F. at equidistant intervals during the period, and then plot out the E.M.F curve. In the same way, by measuring the instantaneous value of the potential difference between the ends of the resistance traversed by an alternating current, we can delineate the form of the current curve for that particular current.

We have, in the next place, to understand what it is that we are able in general to measure in dealing with alternating currents. When the alternating current flows through a wire we may, by means of the instrument above described, determine the instantaneous values of that current. But this is not what, in general, we wish to do, neither are we much concerned with the true mean value of that alternating current. In by far the larger number of cases the only thing that we want to know, and the only thing that we are able to measure, is the $\sqrt{\text{mean-square}}$ value above explained.

When an electric current flows through a wire it heats it, and the rate of production of heat is any instant proportional to the square of the current strength. Hence, if the current strength is changing from instant to instant, the total quantity of heat produced in the wire in any given time is proportional to the mean of the square of the current strength. Under fixed conditions, the temperature which the wire will assume will depend upon this mean square value of the current; for the wire attains its final temperature when there is a balance between the rate at which the heat generated in it and the rate at which the heat has lost by it. The wire loses heat in three ways—by convection, by radiation, and by conduction. If a wire is enclosed in a tube in such a way that convection is prevented, then the wire attains a final state of temperature, when there is a balance between the rate at which the wire loses heat by radiation, and gains it by internal generation. Under these conditions the temperature, and therefore the length of the wire, is determined, not by the average, but by the mean square of the current strength. If, therefore, the current is an alternating current, the final temperature and therefore the length of the wire enables us to measure this mean square value of the current. In the same way if two conductors, one of which is fixed, and the other movable, are traversed by the same electric current, the electro-dynamic repulsion or attraction between these two conductors, due to the magnetic field around them, becomes a measure of the some mean square value of the current, for at any instant the stress between the conductors is proportional to the square of the current strength flowing through them, and if the current is varying from moment to moment the average value of this stress is a measure of the mean of the square of the current strength. We may therefore employ either of these two physical effects, the heating of a wire by a current, or the mutual stress between two conductors traversed by the same current, to measure the mean-square value of that periodic current.

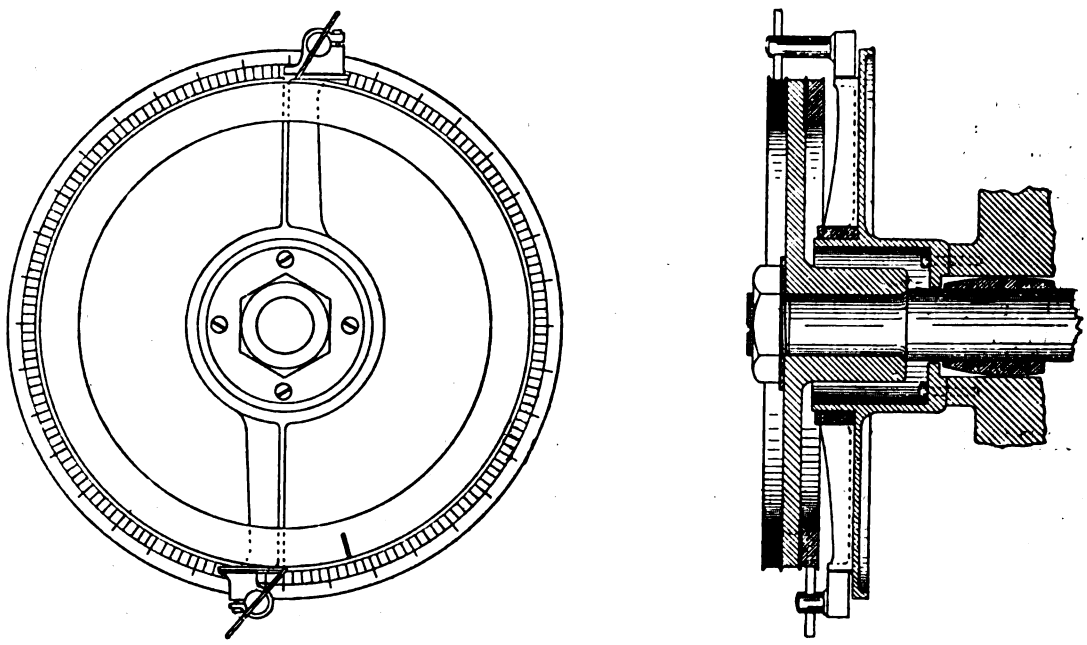

Fig. 1.

So much being understood, it is now possible to point out to you what we mean by an alternating current of one ampere. A continuous current of one ampere has been defined by the Board of Trade Committee as an unvarying current of electricity which, when passed through a solution of silver salt, deposits 0·001118

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gramme of silver per second, or 4·9248 grammes per hour. This may be taken as the practical definition of what is meant by an electrical current having a strength of one ampere when that current is an unvarying current. An alternating current cannot, however, be estimated by such an electro-chemical method, but it is defined as follows:—An alternating current of one ampere is understood to be a periodic current which, when passed through a conductor, brings this conductor to the same final steady temperature as an unvarying current of one ampere would do when passed through it under the same conditions. It is, therefore, an alternating current whose √mean-square value is unity, assuming the instantaneous values to be measured in fractions or multiples of an ampere. Having defined our unit of alternating current, and the two particular general methods of the √mean square value, I may show you two experiments illustrating these facts.

Fig. 3 represents an instrument which I have designed for some other purposes, but which is practically an apparatus for the measurement of the expansion of a wire. It consists of a wooden stand, A B, having a sliding rod, *a*, at one end, pushed forward by a micrometer screw, M, and at the other end a system of levers,

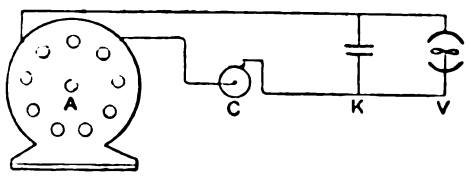

Fig. 2.

c, *d*, *e*, moving a mirror, *m*, from which a ray of light is reflected on to the screen. The micrometer rod and the system of levers are connected by a very fine copper wire, *w*, about 15in. long. On passing a continuous current of electricity through the wire, the spot of light on the screen changes its position, indicating that the wire has elongated. I can then, by means of the screw, bring the spot of light back to its old position, and thus measure the elongation of the wire, and therefore its mean temperature. Performing then the same experiment with an alternating current, which is adjusted to give the same expansion to the wire, I know that I have now passing through the wire an alternating current, of which the √mean-square value is equal to the value of the continuous current. Such a thermal instrument may be modified in many ways, and we shall presently see the forms it assumes; but in all of them the same principles are, in practice, employed.

In the next place, let me direct your attention to another apparatus, intended to illustrate the electro-dynamometer method of measuring alternating currents. An electro-dynamometer is an instrument which consists of two coils of wire, one of them fixed and the other movable. The movable coil is placed with its axis at right angles to that of the fixed coil, and when one and the same

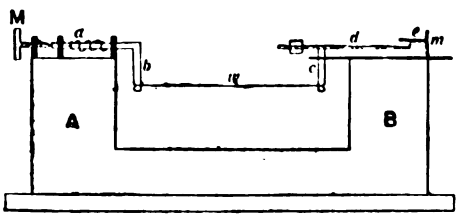

Fig. 3.

current is passed through the coils, the movable coil tends to turn round so as to place its axis in line with that of the other. But by twisting round the suspending wire we can bring the coils back to their original position, and this amount of twisting is a measure of the mean square value of the current strength flowing through the coils. If, therefore, the current varies from instant to instant, the force which is required to hold the movable coil in any given position varies as the average of the square of the strength of the periodic current. Hence, by means of these instruments, as by means of the hot-wire apparatus, we can measure the mean square value of the periodic current. Whilst speaking of this instrument, I will point out one fact which is of practical importance. We know that if a copper plate is held in front of an alternating electromagnet it is repelled, and similarly, if a copper plate is held near the movable coil of this dynamometer, it in like manner repels the movable coil when that movable coil is traversed by an alternating current. I shall afterwards have to point out the practical importance of this fact.

Before going on to discuss in detail various classes of practical instruments which depend upon the principles just explained, it may be convenient to give here a brief classification of electric measuring instruments. The table below will show that these instruments may be classified into six divisions, depending on the kind of quantity they are intended to measure. They may also be classified into five species, depending on the particular physical principle which is employed in the instruments. It is not, however, every one of all possible varieties of such instruments that exists. Those instruments which have practically been made are indicated by an asterisk in the table below:—

	Electro-dynamic.	Electro-magnetic.	Electro-thermal.	Electro-chemical.	Electro-static.
Ammeters or current meters	*	*	*		
Voltmeters or pressure meters	*	*	*		*
Ohmmeters or resistance meters		*			
Coulomb meters or quantity meters				*	
Erg meters or energy meters	*	*			
Watt meters or power meters	*	*			*

Taking, then, the first species of instruments, namely, those depending on electro-dynamic force, I will proceed to describe the valuable instruments invented by Lord Kelvin. Broadly speaking, these instruments may be described as electro-dynamometers, in which there are four fixed coils, around or between which are placed two movable coils attached to a balance arm. The particular point to notice in these instruments is the manner in which the balance arm which carries the movable coils is suspended, so as to permit the coil to move freely, and will enable us to get the current into and out of the movable coils. Lord Kelvin solved that problem by the highly ingenious arrangement of suspending the balance arm by a large number of very fine copper wires. These flexible ligaments of copper are fixed at one end to a pair of fixed copper trunnions, and the other ends to projecting copper lugs attached to the balance arm. When the balance arm is in equilibrium the movable coils occupy a position between the fixed coils, and the connection of the circuits is such that the current can be passed through the whole of the coils in series. When this current so passes it brings into existence forces of attraction and repulsion between the fixed and movable coils, and the balance arm is tipped over in one direction. Equilibrium can then be restored by moving a sliding weight along a tray attached to the balance arm, and when the balance is obtained the position of this weight can be read by means of a scale. By the principles above explained the force required to hold the beam in its position of equilibrium is proportionally to the square of the current strength, and accordingly the beam can be graduated in such a manner as to read off currents directly.

In accordance with what has been above said, it is necessary, when these balances are used for alternating currents, to avoid bringing any metal piece into contiguity with the coils. Accordingly the base of the balance is made of slate, and the coils wound on either slate or porcelain bobbins, or on some material which is a non-conductor. The balance is calibrated for use by means of a steady current, and it is then available for use with alternating currents. Lord Kelvin has devised a whole series of these instruments, which are capable of measuring currents from $\frac{1}{1000}$th of an ampere up to 1,000 amperes, and each instrument has a range of about 1 to 100.

A reference has already been made to the electro-dynamometers of Siemens, which are illustrated in Fig. 4. In all these dynamometers there is a fixed coil and a movable coil, both of which are traversed by the current to be measured. The current is got into and out of the movable coil by means of mercury cups, and the movable coil is brought back to its normal position when diplaced by the current by means of the torsion of a spiral spring. Another instrument of the electro-dynamometer class, but involving a slightly different principle, is one which I devised many years ago, and which depends on the principle of the repulsion of a copper disc by an alternating current. In this instrument there is a fixed coil of wire, which is traversed by the current to be measured. In the interior of this coil of wire there is a small copper disc, which is suspended by a fine wire. The disc is so placed that in its normal position its plane is inclined at an angle of 45deg. to the axis of the corner. When an alternating current is sent through the coil the copper disc turns round so as to place its plane in the direction of the axis of the coil. The torsion of the wire resists this movement, and the copper disc takes up some position of equilibrium. An instrument of this kind can be made to measure very small alternating currents, such as those of about one-thousandth of an ampere. Quite recently I have determined the law of deflection of this instrument, and I find that the angular displacement of the disc from its position of equilibrium is closely proportional to the square of the current strength passing through it. By attaching a mirror to the copper disc, the angular movements can be very much magnified, and the instrument then becomes available for detecting small alternating currents.

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We must next pass on to consider instruments which depend on electromagnetic action, and in order to understand the principles on which such instruments act, we must investigate one or two elementary facts with regard to the behaviour of iron in a magnetic field. If I place a small coil in a horizontal position in the field of an optical lantern, and in the centre of that coil I suspend a small fragment of iron ; on passing an alternating current through the coil, the piece of iron is drawn away from the centre of the bobbin, and moves up against the side. The explanation of this fact is that a piece of soft iron, when placed in a varying magnetic field, tends to move from places of weak to others of stronger magnetic force, and other things being equal, the force so displacing the iron at any point is proportional to the product of the strength of the field, and the rate of change of the field at that point. We may show the experiment in another way. If we place a sheet of glass over the coil, and sprinkle on it some iron filings, and then pass a current through the coil, the iron filings all move outwards from the centre of the bobbin to the edge, the reasen for this being that the magnetic field of the bobbin is weaker at the centre than it is close up against the wire. This principle is employed in the construction of a large number of instruments. Some of Prof. Elihu Thomson's instruments depend on this principle.

In these instruments a small plate of soft iron is attached to an axis which passes through the centre of a bobbin in such a manner that, if the iron is displaced from the centre to the edge of the bobbin, that movement is indicated by a needle. Hence, when an alternating current is passed through the coil, forces are brought to bear on the iron, tending to displace it from the centre to the edge of the coil. A weight is so arranged as to resist this movement, and the instrument may be calibrated for different current strengths, and constitutes what is called the gravity instrument, because no springs are used in its construction.

Another very similar instrument is that devised by Von Dobrowolsky. In this instrument, which is intended for the measurement of alternating currents, there is a coil of wire (Fig. 5), and in this coil of wire is suspended a very slender fragment of iron wire. When an alternating current is passed through the coil, the iron is drawn down into the coil, owing to the tendency it has to move from weak to strong places in the field. This movement of the iron is resisted by the gravity of a small weight. A needle, attached to the axis which carries the fragment of iron wire, moves over a graduated scale, and the instrument can be calibrated as an alternating current ammeter.

Another instrument depending on the same principle is that of Nalder. In this instrument, which resembles in general construction the ammeter of Elihu Thomson, there is a fixed coil through which the current to be measured passes, and on an axis passing through this bobbin there is fixed a small plate of iron ; the field of the binder is made stronger in one part than in others by placing a fixed plate of iron in the opening of the bobbin. When a current is passed through the coil, the movable plate of iron is drawn towards the fixed plate, and in so doing turns round the axis to which it is attached. A needle fastened to the axis moves over a divided scale.

A fourth instrument depending on the electro-magnetic principle is that of Mr. Evershed. In Evershed's alternating current ammeter there is a fixed coil of wire through which an axis passes. This axis carries a small piece of soft iron like a hammer, which is fixed to the axis. Within the coil there are two soft iron cheeks, and between these is formed a strong magnetic field when a current passes through the coils. On passing the current, the movable piece of iron is drawn down between the two fixed cheeks, and this movement is resisted by a weight carried on the axis. The piece of soft iron, therefore, takes a definite position under any given current which depends on the relative forces acting upon the piece of soft iron. In these electromagnetic instruments it is important to know that in employing them for alternating currents the majority of them have to be calibrated for the particular frequency at which they are to be used. We must not take it for granted in using an instrument of this class that its readings will be identical for alternating currents of different frequencies. In the Evershed ammeter, however, a compensation is provided to meet this difficulty, and to make the instruments give identical indications, although the frequency of the alternating current may be varied. The working coil is shunted by an inductive shunt ; this shunt takes about 6 per cent. of the total current as direct currents, but only about 2 per cent. as alternate currents. The result is that the working coil takes about 2 or 3 per cent. more current with alternate currents, and eliminates any error due to eddy currents set up in the bobbin frame and case.

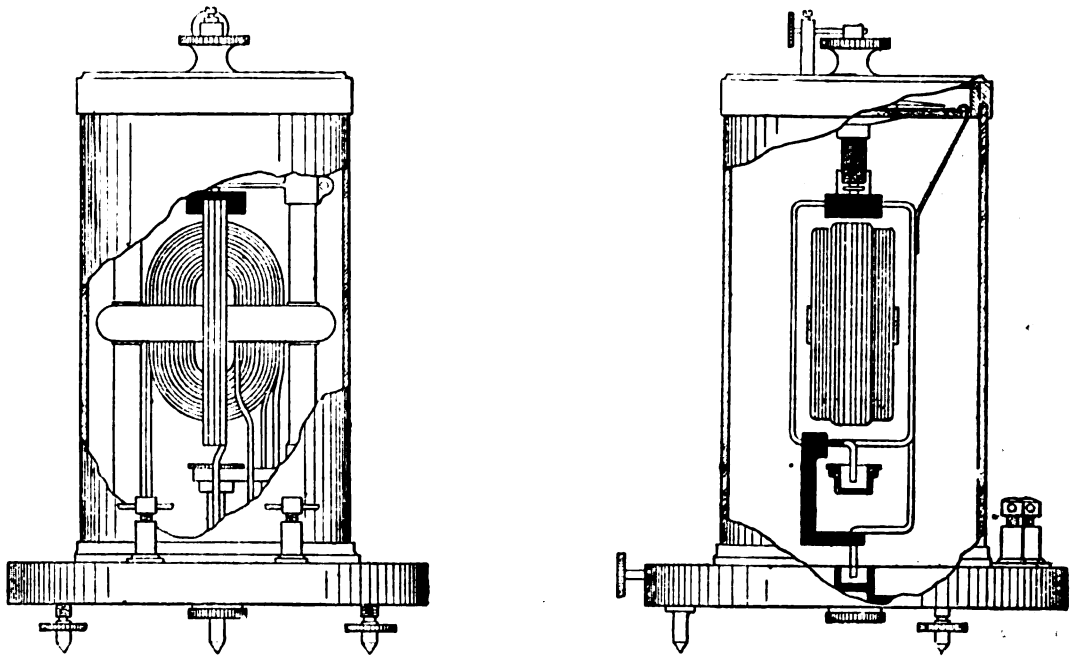

Fig. 4.

Before leaving the subject of electro-magnetic instruments for the measurement of alternating currents, I may mention one instrument which can be employed for the measurement of such small currents as those produced by a telephone. In this instrument there is a fixed coil of wire, and in the centre of this coil is suspended a very small fragment of soft iron wire, with its axis inclined at an angle of 45deg. to the plane of the coil. The wire is hung up by a cocoon fibre, and, by means of a little fragment of mirror attached to the iron, we can detect the smallest movement of the iron. On connecting a telephone to the coil and singing or speaking to it, the iron needle is deflected. The alternating current produced by the telephone passing through the coils of the instrument creates a magnetic field in the interior, and the fragment of soft iron wire tends to turn round so as to place its greatest lengths in the direction of the field of the corner. Hence the presence of a small alternating current can be detected. By making suitable arrangements and suspending the fragment of wire by a quartz fibre, it is possible to make an instrument sufficiently sensitive to measure the millionth part of an ampere.

I now pass on to consider those instruments for the measurement of alternating currents of strength which depend upon the thermal principle, that is to say, depend for their action upon the heating of a conductor through which the current passes. The first of these, which I will describe, is the one which is called the twisted strip ammeter of Prois. Ayrton and Perry. In this instrument a strip of platinoid is stretched between two supports and twisted round in the middle, so that the two halves of the strip form right and left-handed spirals. When this is

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done, and the strip fixed at its two extremities, if an electric current is passed through it, and heats it, the strip tends to twist up more. If an index needle is attached to the centre of the strip, then the passage of a current through the strip may be made to cause this needle to move over a scale, and the position of the needle at any extent to indicate the current going through the strip. If the strip is enclosed in a tube made one-third of iron and two-thirds of brass, the ends of the strip being

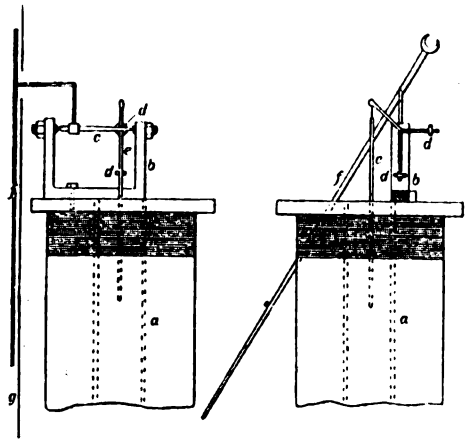

Fig. 5.

attached to the ends of the tube by an insulating support, then no raising or lowering of the temperature of the strip and tube, as a whole, will affect the length of the strip, and hence such an arrangement will constitute a compensation for external temperature. If, however, the strip be supposed to be cooled or heated apart from the tube, it will untwist or twist up more. In order to be able to observe the movements of the strip relatively to the tube, a slit is to be cut in the side of the tube through which the needle attached to the strip can project. In

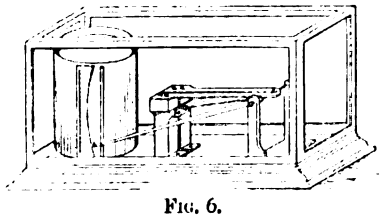

Fig. 6.

the real instrument the tube containing the strip is fixed on to a stout bracket which divides it into two parts, the compound tube having the same coefficient of expansion as platinoid. A needle attached to the centre of the strip projects through a cut in the tube, and moves over a divided scale. If a current is passed through the strip it heats it, and after a short time the strip assumes a certain definite temperature which is attained when there is a balance between the rate at which the heat is generated in the strip, and the rate at which it is radiated to the walls of the enclosing tube. Accordingly, there is a definite position of the needle corresponding to any particular mean

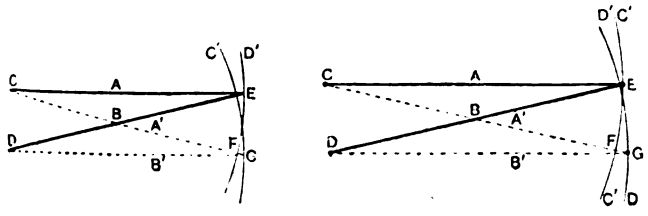

Fig. 7.

square value of the strength of the current, and by passing steady currents through the instrument it can be calibrated for use with alternating currents. Such an ampere meter can be made to read from about 0·2 to 5 amperes, reading by hundredths of an ampere. For the ready measurement of small currents the instrument is convenient, but there are certain difficulties connected with its use which are common to all such thermal instruments.

We may next take note of a very ingenious hot strip ammeter, invented by Major Holden. In this instrument there are two metal strips, and (*see* Fig. 6) of the same length, section, and material. These strips are fastened together by rivets, or otherwise secured at the point, E (*see* Fig. 7), and they are also fastened at the other ends to the framework of the instrument. These strips of metal are each of them of a horse-shoe shape, and, from proper terminals, a current can be passed through one of these strips. If this is the case, the strip becomes heated, and, if one strip is heated, say the top one, whilst the other one remains practically of the same length, the compound strip will be obliged to assume a new position, as indicated by the dotted lines in Fig. 7. This distortion of the compound strip is made to affect a system of levers which multiplies the motion, and an index arm may thereby be caused to move over a scale, or to move a writing pen over a revolving cylinder. It will be seen that a general rise of temperature of both strips simultaneously, such as would be produced by taking the instrument into a warm place, will not affect the form of the compound strip, since each strip lengthens equally, and therefore there will be no turning movement.

In Fig. 8 we have a plan showing the horse-shoe shaped strip, the ends of which are attached to insulated blocks of metal, which form the terminals of the instrument. The controlling strip, which is fastened underneath, and is indicated by the letter B, is a plain strip, riveted at one end to A and the other end to an insulated piece carried on the terminal blocks. Such an arrangement of com-

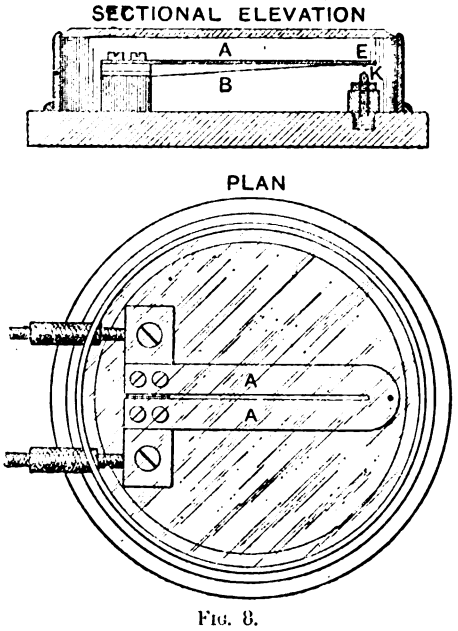

Fig. 8.

pound strips may be employed, not only as an alternating current ammeter, but as a means for closing the circuit when a current is increased above a certain amount. A recording ammeter, made on this principle, which is an exceedingly simple and effective instrument for recording the strength of large alternating currents, and the rigidity of the strip causes the ammeter to be remarkably dead-beat. In the next lecture I shall proceed to describe how these principles are employed in the construction of instruments for the measurement of alternating-current pressure.

(To be continued.)

LEGAL INTELLIGENCE.

Cheslea Electricity Supply Company (Limited) v. London Electric Supply Corporation (Limited).

This was a motion before Mr. Justice Wright on Wednesday last on behalf of the plaintiffs for an injunction to restrain the defendants, their workmen, servants, and agents from laying any distributing main or mains for the supply of electric light within the area described in Schedule A of the Chelsea Electric Lighting Order, 1886, except as provided by an agreement between the plaintiffs and the defendants, dated July 9, 1889, until the trial of the action. In 1889 certain litigation was pending between the plaintiffs and the defendants, and for the settlement of these disputes an agreement, dated July 9, 1889, was entered into between the two companies. By Clause 2 of the agreement (*inter alia*) the London Company undertook that they would not, without the consent of the Chelsea Company, for a period of seven years from the date of the confirmation of a Provisional Order, which was then being applied for by the London Company, voluntarily supply electricity within the area described in Schedule A of the Chelsea Company's Act, and that they would not take any direct action to cause themselves to be required to supply electricity within such area, or to hinder the Chelsea Company

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from supplying within such area, or to compete voluntarily with the Chelsea Company within such area. On the 7th inst. the defendants opened ground southwards in Sloane-square, nearly at right angles to the pipe or pipes in their trunk main near Upper George-street, and they have since carried on the work of opening the ground as far south as the Court Theatre. The plaintiffs' secretary made an affidavit, saying that he believed that, unless restrained by injunction, the defendants would insert distributing mains in pipes or a pipe along the ground they had so opened up and elsewhere in the plaintiffs' area of supply. This, the plaintiffs submitted, would be in breach of the agreement of July 9, 1889. On behalf of the defendants it was contended that the agreement was void as being contrary to the provisions of the Electric Lighting Act, 1882 (45 and 46 Vict., c. 56), Section 11, which provides that "no local authority, company, or person shall by any contract or assignment transfer to any other company or person, or divest themselves of any legal powers given to them, or any legal liabilities imposed on them by this Act, or by any licence, order, or special Act, without the consent of the Board of Trade."

Mr. Justice WRIGHT said that both Companies were bound by Section 11 of the Act of 1882. The defendant Company had agreed that it would not voluntarily supply electricity within a certain area, and it now said that was a void agreement. He thought not. If that was so, the London Company had not overridden the Act by this agreement. The contract was that they would not, until required, supply the electricity. He could not hold this agreement bad. There must be an injunction, in terms of the motion, until the trial.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1893 Edition of "THE ELECTRICIAN" Electrical Trades' Directory and Handbook is NOW READY. This useful book contains over 1,000 pages, and several new and handy features have been added. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

TENDERS INVITED.—The Public Works Department of the Egyptian Government invite offers for the establishment and working of tramway lines in Cairo. The Act of Concession may be had on application from the Minister of Public Works, to whom offers must be sent by February 1st next.

——— The Council of the Borough of Brighton invite tenders for the supply and erection of fittings for lighting the Municipal School of Science and Art on the Grand Parade, Brighton, by electricity. Some further particulars will be found in our advertising columns, and all information can be had on application at the office of Mr. F. J. Tillstone, town clerk, Town Hall, Brighton, to whom tenders must be sent in by 4 o'clock on Thursday, the 31st inst.

TENDERS ACCEPTED.—The Southampton Harbour Board have accepted the tender of Messrs. Donnison, Parmiter and Barber, of Southampton, for the erection of a private telephone between the Board offices and the pier and quay for £30. 15s., including two years' maintenance.

SALES BY AUCTION.—Tuesday, Wednesday and Thursday, September 12th, 13th, and 14th, have been fixed for the sale by auction by Messrs. Wheatley Kirk, Price and Goulty, on the Works premises, Square-road, Halifax, Yorkshire, of the entire contents of the Northern Telegraph Works, including valuable and modern engineering and electrical fixed and loose plant, machinery, dynamos, motors, electrical fittings, stores, batteries, and drawings, patent rights, and other effects, in the matter of Blakey, Emmott and Co. (in liquidation). Catalogues can now be obtained from the auctioneers, 49, Queen Victoria-street, London, E.C., and Albert-square, Manchester; and further particulars can also be had from Messrs. Lakeman and Olliver, 44, Prudential-buildings, Park-row, Leeds.

——— Messrs. Wheatley Kirk, Price and Goulty will sell by auction at an early date on the premises, 11 and 12, New Bridge-street, Ludgate-circus, London, E.C., the modern engineering and electrical plant, loose tools, dynamos, gas engines, &c., to be disposed of under the liquidation of Fawkner, Rogers and Co. Further particulars can be obtained of the auctioneers, 49, Queen Victoria-street, E.C., or of Messrs. Gane, Jackson and Jefferys, 53, Coleman-street, E.C.

LIQUIDATIONS.—The creditors of the London Battery Company (Limited) are requested to send their names and addresses and particulars of their debts, not later than October 17th next, to Mr. H. G. Ellis, of 1 and 2, Marlborough-street, Blackfriars, S.E., the liquidator.

——— The Windsor and Eton Electric Lighting Company (Limited) has suspended operations, and is now in liquidation. Current was supplied for the last time on Saturday.

LIQUIDATIONS.—Amongst the trade creditors in the failure of the London Metallurgical Company (Limited), are the following:—

	£	s.	d.
Arcas Plating Company (Limited)	1,188	0	0
Messrs. Ernest Scott and Mountain (Limited)	92	11	0
Messrs. Pfeil and Co.	79	12	10
Messrs. Woodhouse and Rawson United (Limited)	41	18	4
Electrical Power Storage Company (Limited)	38	16	0
National Telephone Company (Limited)	30	15	0
Messrs. Cathcart, Peto and Radford	23	8	7
Messrs. Vaughan and Brown	14	3	5
Messrs. Johnson, Matthey and Co. (Limited)	12	4	2

——— Under the liquidation of the Art Workshops (Limited) accounts have been issued, showing total liabilities £8,772. 3s. 2d., and assets £3,880. 18s. 1d., the latter being absorbed by the claims of the debenture-holders. The total deficiency is £24,938. The failure is ascribed to the action of the debenture-holders in taking possession of the assets at a moment's notice, to insufficiency of capital, and to want of careful management.

TELEPHONE COMPANY OF IRELAND (LIMITED).—The resolution passed on July 20th for the winding up of this Company was confirmed on August 5th. Messrs V. B. Dillon, Arthur Dudgeon, and Gilbert Cockburn were appointed liquidators.

COMPOSITION.—A meeting will be held at Messrs. Nairn and Bowes' offices, 140, Hope-street, Glasgow, on the 26th inst., at 12 o'clock, to consider an offer of composition by Mr. W. McWhirter, electrical engineer, Campbell-street, Govan.

APPOINTMENTS.—Mr. A. E. Pullen has been appointed by the City Council assistant electrical engineer for Huddersfield, at a salary of £130 per annum. Forty-six applications were received, which were ultimately reduced to four, out of which number Mr. Pullen was selected.

——— Mr. Dalton has been appointed tester in the Bradford Corporation Electrical Works, at a salary of £150 per annum; the appointment to be for three months.

APPOINTMENTS VACANT.—The Toxteth Local Board require an electrical inspector in connection with the Toxteth Park Electric Lighting Provisional Order. Applications must reach Messrs. North, Kirk and Cornett, clerks to the Board, 15, Lord-street, Liverpool, not later than noon on Wednesday, the 30th inst. Further particulars are given in our advertisement columns.

——— A science master is required for the borough of Brighton Municipal School of Science and Art, salary £200 per annum; also a science master for evening classes in mathematics, magnetism and electricity, &c., salary £120 per annum. Further particulars can be obtained of Mr. F. J. Tillstone, town clerk, Town Hall, Brighton, to whom applications must be sent in not later than 10 o'clock a.m. on the 28th inst.

MESSRS. G. E. BELLISS AND CO.—Notice is given that the partnership hitherto subsisting between Mr. George Edward Belliss and Mr. Alfred Morcom, trading as G. E. Belliss and Company, Ledsam-street Works, Birmingham, has been dissolved by mutual consent, and all debts due to and owing by the late firm will be received and paid by Messrs. G. E. Belliss and Co. (Limited), which has acquired and will continue the business as from June 30th last. Particulars of the reconstructed firm will be found in our issue of the 18th inst., page 431.

MESSRS. CLARKE, CHAPMAN AND CO. (LIMITED).—This firm report that their electrical department is well employed, and that, judging by the number of ship installations they are carrying out on the Tyne and elsewhere, their latest type of slow-speed combined engines and dynamos seems to be giving general satisfaction. Sixteen steamers of various classes are at the present time being fitted up with the electric light, including the Japanese cruiser the "Yoshino," building at Sir W. G. Armstrong, Mitchell and Co.'s Elswick Yard (for which Messrs. Clarke, Chapman and Co. are supplying the search-light projectors), and three large passenger steamers building to the order of the Norddeutscher Lloyd Company. Amongst recent contracts obtained is the lighting of Messrs. Ferguson Bros.' large dye works at Carlisle. The firm are issuing a small book containing instructions for the management and control of generating plant and installations in general, and of their own make in particular, besides other electrical memoranda. It is a handy pocket size.

MESSRS. DRAKE AND GORHAM.—This firm have secured the lighting contract for Balliol College, Oxford, and fittings are to be made to suit the special character of the building.——Branch offices have been opened at 100, King-street, Manchester.

LOST.—Messrs. Drake and Gorham, of 66, Victoria-street, Westminster, S.W., have lost a book containing some original testimonials, and anyone returning the same to them, or giving such information as will lead to its recovery are offered £5 as a reward.

A. P. LUNDBERG'S CATALOGUE.—We have received an illustrated price list of Mr. Lundberg's well-known switches, sockets, and

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other fittings. The "Unique" switch, his principal speciality, is, as far as we know, the only practical switch that cannot possibly be held in such a position than an arc can be wilfully produced, having a sudden snap on and off. The catalogue shows one or two of the modifications of this switch for special purposes, such as a "two-way." Several wall sockets are made by Mr. Lundberg, the one with a "Unique" switch would be an admirable one were it not that the cord is continually twisted in one direction. The "centric" wall socket presents several good points, but, as in some other of these manufactures, vulcanised fibre is employed. If slate or some reliable insulator could be employed, this would be seen to be a very useful appliance, being more simple than most wall-socket switches. Lengthening plugs and twin socket plugs are among the other useful fittings offered in this catalogue.

AYR.—The Town Council have received a notification from the Board of Trade that they are prepared to grant further time for the carrying out of the provisions of Section 17 of the Ayr Electric Lighting Order, and have extended the time for one year from August 4th last.

BRECHIN.—At the last meeting of the Public Commission Mr. Jamieson gave notice that he intended moving that an electric light installation, sufficient both for the new police offices and library, be erected, and that the Lighting Committee be empowered to obtain specifications to be drawn up by an electrical engineer.

COOKING BY ELECTRICITY.—The *Pall Mall Gazette* of the 17th inst. contains an article earnestly advocating the extension of electric cooking, and calling upon those supplying the necessary apparatus to bestir themselves and "take the tide at the flood." The article is based upon the recent five-course dinner cooked by electricity in Manchester. "It is by such displays that electric cooking must stand or fall, and there are many reasons for hoping that it will stand."

COVENTRY.—The Electric Lighting Committee of the City Council have presented a detailed report on their investigations into the lighting of the city by electricity. The Provisional Order expired on June 11th last; but the Committee think it unlikely that the Board of Trade will revoke the Order if the Corporation now proceed to exercise their powers with due expedition. The Committee are of opinion that the time devoted to inquiries has been profitably spent, and that the time has now come when operations for the lighting of the city by electricity should be commenced. Schemes had been received from the Brush Company, Messrs. S. Z. de Ferranti, and Messrs. Hammond and Co., recommending a high-tension alternating-transformer system, with a station near the cotton mill; and one from the Electrical Power Storage Company, recommending a high-tension direct-current system, with sub-stations and storage batteries, the generating station to be at Pool Meadow; whilst the Electric Construction Company and Messrs. J. H. Holmes and Co. recommended a low-tension direct-current system, with or without storage batteries, the generating station to be at Pool Meadow. In comparing the estimates which accompanied these schemes the Committee considered the high-tension alternating transformer system involved the smallest capital outlay, and was the best adapted to the needs of the city. Alternative schemes have also been submitted by Messrs. Siemens Bros. and Co., one on the high-tension alternating transformer system, the other on a system combining high-tension alternating generation with low-tension continuous-current distribution, and the estimates forwarded with the schemes confirm the Committee in their views as to the greater cheapness of the high-tension alternating transformer system. In the selection of the type of boilers and engines to be adopted the Committee show a preference for engines of the horizonal slow-speed type, with Lancashire boilers. It is recommended that operations begin with a small generating station, with a view to adding to the plant from time to time as required, so as to reduce the initial outlay as much as possible. Having proceeded so far the Committee invited those firms who had recommended a high-tension alternating current system to submit amended estimates and specifications for a station capable of supplying current to about 4,300 8-c.p. lamps with a distributing system adapted for 12,000 similar lamps, and in the end selected those of the Brush Company and Messrs. Hammond and Co. (the latter coupled with Messrs. John Fowler and Co., of Leeds). A site for a central station in Sandy-lane, which is near both railway and canal, is being negotiated for. The estimates submitted by the various firms do not include buildings, or builders' work. The Committee accordingly recommended that the above arrangement be adopted, and that they be empowered to employ a consulting engineer to advise them upon the selected plans and specifications, and an architect to prepare plans and specifications for the necessary buildings. The Committee believe that the amount required will not exceed £15,000, including buildings, &c. A discussion ensued, in which support was almost unanimously given to the recommendations of the Committee, and the report was ultimately adopted without dissent.

DERBY.—In connection with the electric lighting of this town the work is so well in hand that operations have already commenced for the erection of the large lamp pillars (of which 160 will be erected) to carry the Brockie-Pell lamps, which are being used for the street lighting.

DERRY.—Satisfactory progress is being made with the electric lighting works, generating plant, electric lighting machinery and apparatus, &c., and it is anticipated that the light will be supplied about October. Many of the owners of the large mills and factories in the district have either decided to adopt the light or have the matter under consideration.

DUBLIN.—The Public Libraries Committee of the Corporation recommend that Capel-street Library be lighted electrically. The discussion on the report, which was informal, was adjourned.

EASTLEIGH.—The Local Board last week discussed the question of the indifferent lighting of the principal thoroughfares of the district. Mr. Hazel was strongly in favour of the electric light, which he stated would cost rather less than the present cost of gas. A proposal that the electric light be substituted for gas, and that the Local Board borrow £4,000 for electric lighting purposes, was, however, defeated.

EDMONTON.—At the last meeting of the Board of Guardians, the subject of the advisability of electrically lighting the Edmonton House was discussed, and the Clerk was instructed to obtain estimates for two installations. The subject of introducing the electric light is discussed in the local Press, with special reference to the lighting of the new library and town hall about to be built.

FLEETWOOD.—It has been decided to obtain further tenders for the works in connection with the electric light.

HALIFAX.—Last week a Local Government Board inquiry was held relative to an application by the Corporation for powers to borrow £30,000 for electric lighting purposes. The proposal was opposed by the Halifax Mutual Electric Light and Power Company (Limited), who claim that they have been unfairly dealt with by the Corporation in connection with their electric lighting undertaking. Evidence was given by Mr. T. P. Wilmshurst, electrical engineer to the Corporation, who said he had prepared a scheme and estimate in accordance with the Provisional Order. He had received certain tenders in connection with the work, all considerably below his estimate. His scheme had had the approval of Mr. W. H. Preece, who had visited the sites suggested for the central station. The cost of laying the mains, &c., throughout the compulsory area would be about £27,000, and the plant estimated for would be sufficient to provide 10,000 lights, but mains sufficient to supply 30,000 would be laid. At present it was proposed to expend £9,000 on mains, but the area was an extensive one. With regard to the opposition of the local Company, the Town Clerk stated that the question of the electric lighting being in the hands of the Corporation was made a test at the last municipal election, and those gentlemen pledged in regard to it were returned. At the close of the inquiry the Inspector was understood to agree to the Town Clerk's view that the Board had practically already sanctioned the Corporation's scheme.

HUDDERSFIELD.—£5,000 has been taken on loan from the Borough Fund by the Electric Lighting Department of the City Council. An extension of the electric supply main for a further distance of 25 yards along Queen-street, South, to supply Milton Church, has been decided upon, and the Masonic Hall is also to be connected. The Council have received an offer from the Edison and Swan United Electric Light Company (Limited) to be allowed to exhibit electric light fittings and apparatus at the Corporation's works at the Company's expense, but the offer was declined on the ground that it would be unfair to other firms in the same line of business. The decision of the Council in the matter met with some opposition, many of the councillors considering that the electric light being new to the town, it would have given intending purchasers of fittings an opportunity of viewing the latest design.

JOHANNESBURG.—A correspondent informs us that electrical business at Johannesburg is very dull, and that he "would not advise any young fellow to go to Johannesburg in anticipation of electrical work, as there are already too many electrical engineers in the district."

KELSO.—Newton Don, the residence of Mr. C. B. Balfour, has been completely installed with the electric light, power for which is supplied from the Lynn waterfall; 300 incandescents are used, and the current is also employed for domestic purposes. The work has been carried out by Messrs. A. A. C. Swinton and Co.

KILLARNEY.—The Asylum Board, at their last meeting, passed a resolution approving of the introduction of the electric light in lieu of gas, and decided to advertise for tenders for an installation of 450 lights, on a specification to be drawn up by the Engineer to the Board of Control, who are to carry out the work. An amendment calling upon the Board to abandon all proceedings in connection with the electric light was defeated.

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LEICESTER.—A public meeting promoted by the Leicester Ratepayers' Association was held last week in the Market-place, to protest against the borrowing by the Corporation of £50,000 for the purposes of the electric light supply. Resolutions supporting the object of the meeting were duly carried, and the action of the Association approved. "Other speeches (the *Daily Post* says) followed, and a collection having been announced, the meeting began to disperse."

MONTROSE.—It has been decided to build a new chimney stack, and to put down mechanical stokers, fuel economisers, and other improvements, at the Montrose Asylum, at an estimated cost of between £700 and £800. This additional plant is chiefly required in connection with the electric light.

NEWCASTLE-ON-TYNE.—At the meeting of the Town Moor Management Committee on Tuesday, it was decided to ask the Town Council's sanction for lighting by electricity the proposed fountain in the centre of the lake in Hoyle's intake.

PARTON.—It is rumoured that the Lowca Engineering Company contemplate laying down plant for the production of the electric light, and that they will offer to supply the electric light in the district.

RICHMOND (SURREY).—A circular has been issued by Messrs. Latimer Clark, Muirhead and Co., the contractors for the electric lighting work, to the effect that the electric current will be turned on from the new central station on October 1st, and asking those who are desirous of making arrangements for wiring their premises to send in their applications without delay.

SOUTHAMPTON.—In the report of the Works Committee, just presented to the Harbour Board, it is stated that the electric crane recently erected is giving the utmost satisfaction.

WORCESTER.—The Board of Guardians last week discussed the decision come to by the City Council to adopt the electric light, and it was suggested that the Guardians should reconsider their decision and adopt the light for the new workhouse. The matter is to come up for discussion at a future date.

PATENT RECORD

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

July 28, 1893.

14,556. R. T. PRESTON and A. B. GILL. London. Improvements in apparatus for raising and lowering bodies applicable, for instance, to electric and other lamps and railway carriage and other blinds, and to hoisting gear.

14,562. H. W. RAVENSHAW and L. B. ATKINSON. London. Improvements in alternate-current dynamos and synchronising motors.

July 29, 1893.

14,628. F. HURTER. London. Improvements in or connected with cells or batteries for use in electrolysis.

16,335A. E. M. HARRISON. London. Improvements in induction coils. [Date claimed under Patents Rule 19, September 13, 1892.]*

16,335B. E. M. HARRISON. London. Improvements in magneto electric generators. [Date claimed under Patents Rule 19, September 13, 1892.]*

16,335C. E. M. HARRISON. London. Improvements in electric bells. [Date claimed under Patents Rule 19, September 13, 1892.]*

July 31, 1893.

14,640. A. R. UPWARD. London. A form of water actuated electric switch.

14,643. P. A. BEBOUTOFF. Middlesboro'. Beboutoff's automatical and electrical pile or monkey driver.

14,647. C. ANDERSON. Leeds. Improvements in apparatus for working electric tramways by means of underground cables.

14,664. J. A. KINGDON. London. Improvements in electromotors for alternating currents.

14,685. L. H. HORDERNE. London. Improvements in and relating to apparatus for heating and warming by electricity.

August 1, 1893.

14,715. E. G. HARCOURT. Birmingham. Improved bell-pull arrangement for electric bells.

14,742. F. W. PLUMSTEAD and H. H. HUNTER. London. Improvements in or appertaining to electric light fittings.

14,756. A. G. BROOKES. London. Improvements in dynamo-electric generators and motors. (H. J. Ryan, United States.)*

August 2, 1893.

14,816. A. A. LATEULÈRE. London. An improved electromotor for boats and like purposes.

August 3, 1893.

14,863. A. CAMPBELL. Londonderry. Improvements in electrical resistances.

14,868. J. THOMSON. Glasgow. Improvements in electricity meters.

14,910. P. JENSEN. London. A method of and apparatus for electrolytical decomposition while using quicksilver as cathode. (A. Sinding-Larsen, Norway).*

August 4, 1893.

14,953. T. B. SHARP. Birmingham. Improvements in regulating the supply of electricity to incandescent lamps.

14,966. E. MORWAY. London. Improvements in the construction of loud-speaking micro-telephones.

14,969. F. M. NEWTON and T. HAWKINS. London. Improvements relating to two-pole dynamos, motors, and the like.

14,997. E. EDWARDS. London. Improvements in electric contacts for telegraphic vibrators. (P. la Cour, Denmark.)

August 5, 1893.

15,025. F. A. J. FITZGERALD. Dublin. An electric plant protector.

15,034. T. J. GOUGH. Manchester. An improved electrical and clock-work combination apparatus for the recording of workmen's time and like records.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

13,375. SPENCE. Electric meters, &c.

14,064. ALDRED. Electric current machine and motor.

15,066. WEBBER and NISBETT. Electrical cut-outs.

15,840. CROMPTON and POCHIN. Electric arc lamps.

16,571. WOODHOUSE and RAWSON UNITED (LIMITED) and RAWSON. Electric motors.

16,644. SIEMENS BROS. and Co. (LIMITED) (Siemens and Halske). Measuring electrical currents.

16,805. SCOTT. Electric search-light apparatus.

16,877. FORBES. Telephone signalling apparatus.

16,892. TOMMASI. Extracting, separating, &c., metals by electrolysis.

16,893. TOMMASI. Extracting, separating, &c., metals by electrolysis.

17,160. KINGSBURY (Western Electric Company). Telephone switchboard apparatus.

17,246. RAWLINS. Electric batteries.

1893.

519. LAKE (Weston). Electric resistance boxes.

6,975. BERRY and HARRISON. Electric circuits.

8,330. CAMPANY. Electric car brakes.

9,302. PREWITT. Contracts for electric railways.

9,353. BINSWANGER. Electric lighting, &c.

9,821. LAKE (Whitney Electrical Instrument Company). Galvanometers.

11,099. LAKE (Colby). Electric glow lamps.

11,578. THOMPSON (Coffin). Electrically welding metals.

11,608. MCELROY. Electrical heaters.

11,609. MCELROY. Electric switches.

11,680. SAUER and HENTZSCHEL. Electric alarm apparatus.

12,457. URQUHART and SMALL. Electric conductors.

COMPANIES' MEETINGS AND REPORTS.

The Oriental Telephone and Electric Company (Limited).

The thirteenth ordinary annual general meeting of this Company was held on Wednesday, at the Cannon-street Hotel, under the presidency of Mr. William Addison.

The SECRETARY (Mr. Alexr. B. Chalmers) read the notice calling the meeting.

The CHAIRMAN then said: Gentlemen, in moving the adoption of the report and balance-sheet, I am pleased again to be able to congratulate the shareholders on the steady increase in our business, although, as mentioned in the report, the depreciation in the value of silver has prevented our showing any great improvement in the net results of the year's working as compared with those of last year. However, in these times of commercial depression an increase in the amount of business done is in itself satisfactory, and it is solely owing to causes over which we have no control that the profits have not been proportionately better. You will see from the report that the appeal to the House of Lords has been allowed, and consequently there is a sum of about £13,000 owing by the holders

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of Vendors' shares on account of interest payable to the holders of Ordinary shares during the first five years of the Company's existence. I may mention for the benefit of those who have not followed the matter closely how this litigation came about. It was in this way:—The question of the legal interpretation of a clause in the original agreement was raised by an eminent actuary some three years ago, who was consulted as to the relative values of Vendors' and Ordinary shares, and in consequence your Board was advised to commence a friendly action in Chancery for the purpose of getting an authoritative decision, and was prepared to accept such decision as final; but some of the holders of Vendors' shares, after waiting nearly twelve months, appealed. The Court of Appeal reversed the decision of the lower Court. As the two Courts differed, your Board had no alternative but to take the matter to the House of Lords for final decision. That decision we have now got, and litigation, which is always to be deplored except by the lawyers, has ceased. I am glad to inform you that after many representations to the Government of India, both on this side and in India, in regard to the competition of the Indian Telegraph Department, through that Department installing and undertaking to supply telephonic communication in districts for which they had granted licences to us, the Government has seen fit to withdraw from competition in these specially-reserved districts. It certainly did seem unreasonable that the Telegraph Department should compete with our subsidiary Companies and ourselves, and at the same time extract royalties from us. In looking at the profit and loss account, you will see that there is a balance of profit of £9,085. 5s. 11d., and adding to that £1,957. 16s. 4d. carried forward from last year, there is a sum of £11,013. 2s. 3d. to be dealt with. Now, the present Board have always in their minds their promise on taking office not to make a call if it can be avoided. To enable them to carry this out it is necessary to provide a substantial reserve fund for necessary and useful extensions, and for the demands of a growing business. We propose, therefore, this year to add a further sum of £2,500 to the reserve fund, which brings it up to £12,500, all invested in Consols, and, therefore, immediately available should money be required. The dividend now recommended is equal to £3. 12s. 2d. per cent. on the Ordinary shares. I do not know what more I can add to what I have already told you, and to what you will find in the report. Our business is sound and progressive, and I think all here will agree with me that the present balance-sheet is certainly the best that has hitherto been presented at any annual meeting of the Company. Before putting the resolution to the meeting I shall be glad to answer any questions.

Mr. HIBBERT said that it was now about fifteen months since they had heard anything from the Directors, and he thought that during that period the Board might have made some communication to the shareholders with regard to the lawsuit mentioned. He had no idea that any decision had been given against them or that there had been any appeal, and he thought that a circular might have been sent to the shareholders giving them this information.

A SHAREHOLDER remarked that this would have entailed expense.

Mr. HIBBERT said that the expense would not have been much. With regard to the balance-sheet, it was most favourable, no doubt, and their position looked very well in regard to the future. He could not understand how their shares were so low, because there was sufficient to pay a dividend of about 12 per cent. on the market value of the shares. It occurred to him that the market price of the shares was owing to the uncalled liability of 9s. a share, the shares being of £1, with 11s. paid. Surely there must be some means of getting rid of this liability, the Directors themselves having stated that they had no idea of making a call. He thought that the shares might be made into 10s. shares, and he commended this point to the Directors for their consideration. The revenue account stated "by net profit on working of the Company's exchanges," &c. He wished to know the actual profit on their exchanges, and where they where. He imagined that the principal part of their profit was derived from their shares in other companies, which was a considerable sum. With respect to the item in the balance-sheet of telephone patents and goodwill, £71,000, that was a very large amount, and he wished to know if there was any real value in their goodwill. He presumed, with regard to the next item of £34,924, that the expenditure had been on their own exchanges.

The CHAIRMAN: That gentleman who last spoke wants to know why we did not send out a circular giving the progress of the different appeals. I certainly cannot see the necessity of doing so, and I fail to see what good it would have done. We had three cases on, and to have sent out the information mentioned would have cost about £5 in each case.

Mr. HIBBERT thought that that would have been a very small amount.

The CHAIRMAN (continuing): The next question is as to reducing the liability on the shares. It has been our object, and it was the principal cause of this litigation to make all classes of shares alike. It was at the wish of one of the largest shareholders that we should take the first decision which we did, and he raised the question of the way of paying the dividend. There was a judgment one way and a judgment another way, and now the House of Lords have supported Mr. Justice Kekewich. All this litigation arose from our trying to have one class of shares, and trying to negotiate with the vendors for that purpose. Now we have this decision, I hope that we shall be able to come to some arrangement with that object.

Mr. KING asked whether it was meant to reduce the liability on the shares having 11s. paid up?

The CHAIRMAN: That has been our object all through—to reduce the liability and to have one class of shares. The profit on the Oriental exchanges was about £4,000. The value of the goodwill stands at £71,000. That represents our business. Unless we had had the goodwill we could not have carried on our business.

A SHAREHOLDER inquired the present value of the shares held in the subsidiary companies?

The CHAIRMAN: There is no market for them, and therefore they remain in the balance-sheet as they were. Their value has not decreased. I may say that much.

Mr. W. S. CUFF remarked that the Chairman had stated why the Directors had added to the reserve fund, and personally he approved their policy. He also considered that they were in a very much better position than they had been for many years now that they had settled the question which had been pending with the vendors. He wished to ask the Chairman why they carried forward such a largely increased balance, and whether they intended in the future to confine the dividend to its present rate for any purpose. He thought that if the liability on the shares could be reduced it would be a benefit to them and would strengthen the value of their property on the market. He thought they might regard their position as much better than it had been, and in his opinion their shares ought to stand at a much higher price.

The CHAIRMAN: I do not say what we may do in the future, but we had this legal action on, and we did not know whether we should gain or lose it. We therefore felt bound to provide for the extra expenses in case of our losing it. This, perhaps, has something to do with the amount carried forward being rather larger than it might have been. He then moved the adoption of the report and accounts.

Mr. HENRY GREWING seconded the motion, which was unanimously adopted.

Mr. B. ST. JOHN ACKERS proposed the re-election of Mr. G. B. Frost as a Director.

Mr. GREWING seconded the resolution, which was unanimously carried.

Mr. THOMAS LLOYD proposed the re-election of Mr. B. St. John Ackers as a Director.

Mr. FROST seconded the motion, which was unanimously adopted.

Mr. BENNETT PELL proposed, and Mr. CUFF seconded, the re-appointment of Messrs. Deloitte, Dever, Griffiths and Co., as auditors, which was carried.

A vote of thanks to the Chairman, Directors, and Staff terminated the proceedings.

Brush Electrical Engineering Company (Limited).

The fourth annual general meeting of this Company was held yesterday (Thursday) at the Cannon-street Hotel, E.C., under the presidency of Mr. J. B. Braithwaite, jun.

The SECRETARY (Mr. B. Broadhurst) having read the notice calling the meeting,

The CHAIRMAN referred with great regret to the loss which the Company had sustained by the death of the late Duke of Marlborough, the former Chairman of the Company. Most of the shareholders were aware of the deep and practical interest which his Grace took in every development of electrical engineering, in regard to which he spared himself neither time, trouble, nor money. He thought that, in common with the whole electrical industry, they had sustained a great loss by his removal from them. Their former manager, Mr. Garcke, had left them to join the fortunes of the Electric Construction Corporation, and they all wished him a very successful future. Mr. Garcke's place had been filled, subject to the shareholders' confirmation, by Mr. Arthur Ayres. Passing to the balance-sheet, he stated that during the past year they had issued a certain amount of additional capital, as was foreshadowed at their previous meeting. The increase of their business had been so consistent and so steady that they had found it necessary again to enlarge the capacity of their works at Loughborough; and the works manager was now crying out for more accommodation, owing to the increase in their orders. They were careful, however, not to make extensions in order to meet any sudden rush of business, but only if they had reason to believe that it would be advisable, in view of future requirements, to do so. They had expended in the year £10,681 on capital account, in additions to plant and buildings at Loughborough. They had issued 15,000 Six per Cent. Preference shares, and 11,617 Ordinary shares. They had obtained a premium on the new issue of shares and debentures of £3,150—a solid testimony to the standing of their Company and the view taken of their prospects by the investing public. The debenture stock had now been raised to its full authorised amount of £125,000. In the item of creditors there was a considerable change in the present balance-sheet compared with that of last year. They now owed £41,000, whereas last year they owed £59,624 to creditors and £19,000 on bills payable. They thus owed £37,000 less than they did a year ago, while they had owing to them £119,540, or £14,000 more. The increase in the item of stock, on the credit side of the balance-sheet, all represented orders, and therefore the increase in this item from £77,900 a year ago to £91,500 was very gratifying. They proposed to write off the whole of the item of preliminary expenses. The balance of foreign and Colonial branches stood at £61,492. The great bulk of the difference of £20,000 in this item compared with the amount at which it stood a year ago was owing to the sale of their station at Temesvar. They proposed out of the available balance of £15,894 to pay a dividend on the Ordinary shares at the rate of 7 per cent. per annum, to write off the whole of the preliminary expenses—£1,575—and to carry forward £815. Passing to the profit and loss account, he stated that there was a slight decrease in the standing charges, but during the current year they anticipated that the economies effected by concentrating all their work at Loughborough would be very apparent, and they hoped to see the item of general charges, now standing at £17,427, considerably reduced. The cost of the removal to Loughborough was an exceptional item, amounting to £1,328. They were left with a balance, being net profit of £26,394. The gross profit for the year, as shown on the other side of the balance-sheet, was £49,405, not including the profits on the Austrian and Colonial branches, but only the profit on their British

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business. By writing off the items of preliminary expenses and the cost of removal to Loughborough, they got rid of the only two items which blocked the way to an increase in the dividend. In spite of the paralysis of business in Australia and the drawbacks they had had to their Austrian business, they were able to show a profit of practically £50,000 on their English manufacturing operations. They stood in a very satisfactory position with respect to orders. Their shops were absolutely full, and the only question with them was whether they could take orders for delivery within the time specified. At their works in England and Austria they were employiug 1,300 men constantly. They had orders in hand at the present time which practically enabled them to see their way to full work until they met that time next year; and orders continued to come in at a satisfactory rate. Their present manufactures appeared to command the satisfaction of those who required electrical machinery, but it was, nevertheless, necessary for the Directors to keep their eyes open for fresh developments. They constantly found fresh inventions and developments, which materially modified and altered the conditions of the industry. They had completed in the most satisfactory manner the large machines they had been building for the City of London Company. It was very necessary in the case of such a Company as that to be able to meet at once emergencies caused by any sudden demand, and the machines which the Brush Company had supplied them with had enabled them to supply their customers without any hitch or difficulty. Their Mordey-Victoria was an alternating-current machine, but it was quite a mistake to suppose that they could only supply alternating-current machines. They claimed to be able to supply continuous-current machines quite as well as any other manufacturers. They had made a satisfactory arrangement with the Otis Elevator Company for the manufacture of the elevators required by them in this country, and they could carry on this work admirably. With regard to their foreign business in Australia the complete financial collapse which had taken place there had brought business in the past year almost to a standstill, but it was very gratifying to him to be able to state that their Company had not been a loser through any of the banks which had failed in the Colony. Their business was intact, and now that affairs were beginning to resume their normal condition, they were again receiving remittances from the Colony. In Austria their profits had suffered a large diminution owing to the immense competition in the glow-lamp business; but they had made arrangements by which they would do far more work in that country, while the glow lamps would not be so important an item to them there that it had been in the past. Practically, up to this time in this country little or nothing had been done in the way of electric traction, but it seemed as if some progress was now about to be made in this direction. They were themselves exceedingly favourably situated in regard to this class of business, for they were not only able to build engines and motors, but also the cars themselves at their Falcon works. He had no doubt that when electric traction came to take a prominent place in electrical industry in this country their Company would get its fair share of the work. With regard to electricity supply stations, a great deal of progress had been made in this country. Electric lighting powers had been secured by 108 municipalities. Of these 28 had applied for authority to borrow money to carry out their powers, and 17 of them had received permission to borrow money. As far as the business of central stations was concerned, the Brush Company were getting their fair share of the work. With respect to general business, it was not necessary for him to go into details. As he had said, 108 municipalities had secured electric lighting powers, but only 17 of them had, so far, received permission from the Board of Trade to carry them out. A considerable number, therefore, had yet to come on. In London the growth of electrical supply in the past two years had been very great. At the end of 1891 the various companies in London had about 300,000 8 c.p. lamps connected to their mains, whilst at the end of 1892 they had about 500,000. It was impossible to say what the number was at present, but they knew that it was well over 500,000 and on to 600,000. The subscribed capital of the companies supplying electricity in the Metropolis was about £3,500,000. These figures showed that the electric lighting industry had emerged from the experimental stage. The number of customers connected to the mains had increased by 60 or 70 per cent., showing that the public were satisfied with the advantages of the light. The City of London Company, with which the Brush Company was more immediately connected, was receiving applications for about 1,000 lamps a week without any canvassing whatever. When they considered that every 8 c.p. lamp displaced an ordinary 5ft. gas burner, one would think that this would mean a falling-off in the gas consumption; but according to what the Chairman of the Gas Light and Coke Company said at the late meeting of that Company, the shareholders in electric lighting companies would now be able to receive their dividends without any fear that they were injuring the gas industry. Col. Makins had discovered that the falling off in the gas consumption was due to temperature, and not to electricity! The expiration of the Edison master glow-lamp patent on November 10th next would probably give an additional impetus to central-station development. The price of the lamp had hitherto been a bar to the progress of the electric light, but with the expiration of the patent mentioned the price would come down to about 1s. 6d.—a reduction which could not but incline many people to adopt the light. After November 10th this Company would be able again to supply the consumer fully—with engines, dynamos, switches, all sorts of fittings, and the lamp as well; and their arragements were complete for the manufacture of glow lamps on a large scale as soon as the Edison patent expired. He concluded by moving the adoption of the report and accounts.

Mr. B. H. VAN TROMP seconded the motion.

A brief discussion followed, and in answer to questions,

The CHAIRMAN stated that they had been running a station at Temesvar for some years, supplying electricity to the town and the public streets with the light. It was not very easy, however, to carry on such a business, and they were not sorry when the town expressed a desire to buy the works, which they had sold for what they considered a fair and satisfactory price. The whole of this money had been received. They did not think it would be to the interest of the Company to divide the item of property, patents, and goodwill. It was not the case that they were paying a dividend by means of the premium obtained on the issue of shares, but he had thought it a wise proceeding to use the money thus obtained for writing off the two items of balance of preliminary expenses and the cost of removal to Loughborough.

The motion was unanimously adopted, and resolutions were afterwards passed declaring the dividends recommended, confirming the election as a Director of Mr. Arthur Ayres, and re-electing the retiring Directors and auditors.

A vote of thanks to the Chairman, Directors, and staff terminated the proceedings.

Direct Spanish Telegraph Company (Limited).

The following is the report of the Directors of this Company for the half-year ended June 30th last, to be presented at the general meeting of shareholders to be held on Friday, September 1st, at Winchester House, E.C., at 12 o'clock:—

The accounts show, after providing for debenture interest, a balance to the credit of profit and loss of £4,645. 13s. 9d. The traffic receipts show a decrease of £593. 8s. 9d. as compared with the corresponding period of 1892. This falling off in the receipts is chiefly due to the stagnation of Stock Exchange business in England, Spain, and France. The working expenses are £130. 6s. 5d. in excess of those for the corresponding period of last year.

The Company's cables, and the land lines in connection with them, have continued in good working order throughout the half-year.

The Directors report, with extreme regret, the death of Sir James Anderson, who had been Chairman of the Board since 1884. At the invitation of the Directors, Sir John Pender, G.C.M.G., M.P., has joined the Board to fill up the vacancy. The Directors also have to report the death of Mr. Herbert R. Duke, the auditor of the Company. They have, in consequence, requested Messrs. Deloitte, Dever, Griffiths and Co. to audit the appended accounts, and an extraordinary general meeting has been convened after the ordinary general meeting to elect an auditor.

After adding the usual sum of £2,500 to the reserve fund, the balance of profit and loss amounts to £2,145. 13s. 9d. To this the Directors propose to add £345. 0s. 10d. from interest on investments, and recommend the payment of the dividend at the rate of 10 per cent. per annum on the Preference shares, and a dividend at the rate of 4 per cent. per annum (free of income-tax) on the Ordinary shares. The reserve fund will then amount to £35,963. 11s. 3d.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1893, pages 320-348, *&c., &c.*]

S. P. CATTERSON AND SONS (LIMITED).—This Company was registered on August 17th, with a capital of £25,000, in £10 shares, to carry on the business of lamp manufacturers, iron, brass, and metal founders and workers, mechanical and electrical engineers, manufacturers of any description of machinery, &c.

EUROPE AND AZORES TELEGRAPH COMPANY (LIMITED).—This Company was registered on August 19th, with a capital of £200,000, in £10 shares, to purchase, acquire, or construct, or cause to be manufactured, wires and cables of all kinds for the purpose of telegraphs and telephones; to acquire, by purchase or otherwise, a concession, dated June 17, 1893, and granted by the Government of His Majesty the King of Portugal to the Telegraph Construction and Maintenance Company (Limited) for the establishment of a submarine telegraph cable between Portugal and the Azores Islands, and for the laying of like cables between certain of those islands; to work the same; and to construct, maintain, and work telegraphs, telephones, and electric light works. The subscribers are:—Sir John Pender, G.C.M.G., M.P., the Most Hon. the Marquis of Tweeddale, T. Fuller, Sir A. J. Leppoc Cappel, K.C.I.E., J. Denison Pender, Admiral Sir G. H. Richards, K.C.B., F.R.S., and W. Shuter, with one share each. The number of Directors is not to be less than three nor more than five. The first are Sir John Pender, the Marquis of Tweeddale, Thomas Fuller, and J. Denison Pender. Qualification, £500. Remuneration, as fixed by the shareholders in general meeting.

MARINE SIGNALS (BARKER'S) SYNDICATE (LIMITED).—This Company was registered on August 18, 1893, with a capital of £6,000, in 5s. shares, to acquire and turn to account patents and inventions relating to marine signalling.

WATERHOUSE ELECTRO-METRIC SYNDICATE (LIMITED).—This Company has been registered with a capital of £20,000, in £10 shares, to ratify and execute an agreement which has already been prepared, and is expressed to be made between Addison G. Waterhouse and A. T. Salisbury Jones, and John J. Dale (acting on behalf of the Company) for the purchase

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by the Company of certain letters patent, patent rights, inventions, &c., and to develop and turn to account the same. The subscribers are:—A. T. Salisbury Jones, H. P. Amholz, J. J. Dale, A. G. Waterhouse, F. W. Salisbury Jones, P. B. Mills, and G. Bidwell, with one share each. The first Directors are subject to the decision of the subscribers.

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to July 26, 1893, was filed on July 31st following, with a nominal capital of £300,000, in £10 shares. 23,600 shares have been taken up, and the full amount called and paid.

AKESTER ELECTRO-MOTOR AND ACCUMULATOR COMPANY (LIMITED). The annual return for 1892, made up to March 25th of that year, was filed in May last. The nominal capital of £5,000, in £1 shares, had all been taken up, and 3,500 of the shares were considered as fully paid. In consequence of the £1 call on the remainder, £1,153. 8s. had been paid, and £346. 12s. not yet received. Since the filing of the above and the return for 1893, 652 shares, on which £475. 12s. had been paid, were forfeited, so that only 4,348 shares are held at present. The calls paid amount to £1,324. 12s., the arrears being £175. 8s.

LINEFF ELECTRIC TRACTION AND LIGHTING SYNDICATE (LIMITED).—In accordance with a special resolution passed June 20, 1893, and confirmed July 10th following, the nominal capital of this Company has been increased from £10,000, in £1 shares, to £15,000, by the creation of 5,000 new shares of the value of £1 each.

SINGLE-WIRE MULTIPLE TELEPHONE SIGNAL COMPANY (LIMITED).—The annual return of this Company, made up to and filed on August 3, 1893, shows that 254 shares, out of a capital of £5,000, in £10 shares, have been taken up, the full amount called, and £2,540 paid.

STOKE-ON-TRENT ELECTRICITY SUPPLY COMPANY (LIMITED).—An application has been made to have this Company struck off the register.

SWINBURNE AND CO. (LIMITED).—The statutory return of this Company, made up to June 29th, has been filed. The nominal capital is £25,000, divided into 300 Deferred and 4,700 Ordinary shares of £5 each. All the Deferred and 1,686 Ordinary shares have been taken up, 200 Deferred have been issued as fully paid, while upon 660 of the Ordinary shares £2. 10s. has been considered as paid. The full amount has been called on the remaining Deferred shares, £3 per share has been called on 1,026 shares, while a call of 10s. per share has been made on the 660 (£2. 10s. paid) Ordinary shares. The calls paid amount to £3,908.

SYNDICATE OF ELECTRICAL ENGINEERS (LIMITED).—The annual return of this Company made up to July 2, 1892, was filed on June 24, 1893. The Company has a nominal capital of £10,000, in £5 shares, of which 1,081 have been taken up; 74 Founders' shares have been issued as fully paid, while a call of £4 per share has been made on the 1,007 Ordinary shares, resulting in the payment of £3,203. 10s., and leaving £824. 10s. in arrears. The usual return for 1893 made up to March 3, 1893, was filed with the foregoing. No alterations have taken place, except that the payments made have increased to £3,753. 10s., and those due proportionately decreased to £274. 10s.

TELEGRAPH MANUFACTURING COMPANY (LIMITED).—The annual return of this Company, made up to June 30th, has been filed. Although the nominal capital amounts to £50,000, in £10 shares, only 2,800 shares have been taken up, of which 646 have been issued as fully paid. The full amounts have been called and paid on the remaining 2,154 shares.

THEATRE ELECTRICAL AND SPECIALITIES PRODUCTION COMPANY (LIMITED).—The authorities have decided to dissolve this Company unless necessary returns are filed in a few days.

THETFORD ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of this Company made up to September 30, 1892, was filed on July 3, 1893. The nominal capital is £5,000, in £10 shares, of which 368 have been taken up. On these a call of £8 per share has been made, resulting in the payment of £2,921, out of a total of £2,944, while a sum of £50 has been paid in advance of calls.

UNITED RIVER PLATE TELEPHONE COMPANY (LIMITED).—The annual return of this Company, made up to July 18th, has been filed. Out of its nominal capital of £500,000, in shares of £5 each, 58,000 shares have been taken up and 16,000 issued as fully paid. The full amount has been called and paid on the remaining 42,000 shares.

WALSALL ELECTRICAL COMPANY (LIMITED).—When the statutory return of this Company was filed recently, 683 shares out of a nominal capital of £10,000, in £10 shares, were taken up; 200 of these were issued as fully paid, and the full amount has been called on the remainder, resulting in the payment of £4,780.

WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).—The recently-filed returns of this Company states that the whole nominal capital of £300,000, in £10 shares, have been taken up and fully paid.

WESTERN COUNTIES ELECTRIC LIGHT AND POWER SYNDICATE (LIMITED).—The first annual return of this Company, made up to August 9, 1893, shows that 205 shares of £50 each, out of a nominal capital of £25,000, have been taken taken up. Of these 120 have been issued as fully paid, while the full amounts have been called, and £4,250 has been paid on the remaining 85 shares.

WINDSOR AND ETON ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to August 7, 1893, was filed on the following day. The nominal capital is £30,000, divided into 5,950 Ordinary shares of £5 each, and 250 Founders' shares of £1 each. 438 £5 and 102 £1 shares have been taken up, the full amount called, and with the exception of £55 the whole has been paid. A notice was filed on August 14th that at special meetings held on July 24th and August 10th it was resolved that the Company could not continue its business on account of its liabilities, and therefore Mr. W. Sevenoakes was appointed liquidator for the winding up of the Company.

WYNNE'S ELECTRIC CLOSED-TUBE TRAMWAYS (LIMITED).—The annua return of this Company, made up to July 1, 1893, has been filed. The nominal capital is £6,000, in £100 shares, of which 54 have been taken up, 32 have been issued as fully paid, while the full amount has been called on the remainder, resulting in the payment of £2,130, and leaving £70 in arrears.

CITY NOTES, &c.

BABCOCK AND WILCOX (LIMITED).—The Directors of this Company have decided to recommend, subject to audit, dividends for the half-year ended June 30th last, at the rate of 6 per cent. per annum on the Preference shares, and 10 per cent. per annum on the Ordinary shares.

BIRMINGHAM CENTRAL TRAMWAYS COMPANY (LIMITED).—At the annual meeting of the shareholders of this Company, held on Wednesday last week at Birmingham (Mr. J. Ebbsmith in the chair), the report and statement of accounts, an abstract of which appeared in *The Electrician* for August 11th, were adopted. Resolutions were passed for the payment of a 5 per cent. dividend on the Guaranteed shares, and 2½ per cent. on the Ordinary stock.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended August 20th were £860, as against £724 for the corresponding period of last year, being a increase of £136. The total receipts for the half-year amount to £5,911, against £5,385 in the corresponding period of 1892, being an increase of £526.

CROYDON TRAMWAYS COMPANY (LIMITED).—In the course of his remarks, at the meeting of the shareholders of this Company on Tuesday, Mr. J. Carruthers-Wain said there was an item in the accounts in previous years relating to electric traction which did not figure in the present accounts. The Electric Traction Syndicate had not been able to renew its running on the Croydon line, or to make any definite arrangement. The Company was therefore without the traffic receipts for this particular form of traction, which, being a novelty, materially assisted the traffic receipts. Some new gas motors had been received for trial, which were being run at the expense of the owning companies. As these experiments cost the Croydon Company nothing they could not do better than facilitate the development of some economical form of traction, which would some day take the place of horses and be the means of saving expense to tramway companies. The arrangement made in regard to these experiments was practically on the basis of sharing profits, the Croydon Company taking no risk.

LEIPZIG TRAMWAYS COMPANY.—Mr. W. Bailey Hawkins, at the meeting of this Company on Tuesday last, said that there was one special fact to which he wished to allude, and that was that unfortunately there had been a considerable agitation in Leipzig recently with regard to the use of electricity as a motive power. He could not give the shareholders any further information on the subject, as he had nothing to form a judgment upon. In reply to a question, the Chairman further stated that the Company had not only no power to use electricity, but it was also a very grave question whether the Municipality would give them the necessary power.

LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company announces that the half yearly coupons, which fall due on September 1st next, of the £100,000 Six per cent. Debentures of the Company will be paid on and after that date by Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, E.C.

MONTREAL STREET RAILWAY COMPANY (LIMITED).—The subscription list closes to-day (Friday) for an issue of £140,000 sterling Four and a-Half per Cent. Debentures of £100 each (redeemable in 1922) in the above Company. The price of issue is £98. 10s. per cent., payable £5 on application, £43. 10s. on allotment, and £50 on September 13th next. Subscriptions are invited by the Bank of Montreal, 22, Abchurch-lane, E.C. The debentures (the prospectus states) are secured on the whole of the property of the Montreal Street Railway Company, and rank with the £60,000 Five per Cent. Mortgage Bonds issued in 1888. Interest is payable in London in February and August in each year, a full half-year's interest being due on February 1st next. The proceeds of the present issue are required for doubling the existing lines, for extensions, and for the necessary outlay for working the whole system by electricity. The Company was organised in 1860, and has a capital of $2,000,000 fully paid up. Dividends paid by the Company for the past 10 years average from 7 to 14 per cent.; for the three last years 8 per cent. has been paid.

TELEGRAPH COMPANIES' EARNINGS IN 1892.—*The Statist* of the 19th inst. contains a carefully-written article on the subject of the results of the Telegraph Companies' Earnings, &c., for 1892, which includes some figures of interest to our readers.

WEST AFRICAN TELEGRAPH COMPANY (LIMITED).—This Company give notice that the half-yearly interest, due on September 1st next, will be paid on and after that date by the National Bank of Scotland, 37, Nicholas-lane, E.C. Coupons must be left three clear days for examination.

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WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended August 18, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,386.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the two weeks ended August 15 were £1,855, as compared with £1,980 for the corresponding period last year. The April receipts, estimated at £6,413, realised £6,441.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price. Aug. 16.	Price Wednesday, Aug. 23.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 23. Highest	Lowest
			TELEGRAPHS			£ s. d.			
£1,134,640	Stock	12/6	Anglo-American	49 50	49 50	5 10 0	Jan., Apr., July, Oct.	49	..
£2,932,680	Stock	25/0	Do. Preferred	91½ 92½	92 93	5 18 3	" "	93	90½
£2,932,680	Stock	5/0	Do. Deferred	9 9½	9 9½	..	.. ..	9½	9⅜
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	99 102	99 102	3 18 5	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11¾ 12¼	11¾ 12¼	5 6 1	Mar., June, Oct., Dec.	12¼	11¾
£36,400	£100	5%	Do. 5 per Cent. Bonds	99 103	99 103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107 111	107 111	4 10 1	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	120 130	120 130	5 7 8	April and October	124	120
16,000	10	8/0	Cuba Submarine	11½ 12½	11½ 12½	6 8 0	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	18½ 19½	18½ 19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½ 3½	2½ 3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	8½ 9½	8½ 9½	5 5 3	" "	..	..
60,710	20	3/6	Direct United States xd	11½ 11¾	11½ 11¾	5 19 2	Jan., Apr., July, Oct.	11¾	11½
400,000	10	5/6	Eastern	14⅜ 15	14⅜ 15	4 6 8	" "	15	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	16½ 16¾	16½ 16¾	3 11 8	" "	16¾	16½
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112 115	112 115	3 9 7	May and November	114½	113½
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	106 109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15 15¼	15 15¼	4 11 10	Jan., Apr., July, Oct.	15½	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	110 113	110 113	3 10 10	February & August	111	..
£70 600	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	102 105	102 105	4 15 3	January and July	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	101 104	100 103	4 17 1	" "	102	101½
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101 104	100 103	3 17 8	February & August	102½	101
£200,000	£25	..	Do. 4% Mauritius Sub. Debs.	..	103½ 104	..	May and November	..	..
180,227	10	4/0	Globe Telegraph and Trust	9⅝ 9⅞	9⅝ 9⅞	4 13 8	Jan., Apr., July, Oct.	9⅞	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	14⅝ 15⅛	15 15½	3 18 8	" "	15	14⅝
150,000	10	5/0	Great Northern	19½ 20	19½ 20	4 5 0	Jan., April, and July	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105 108	105 108	4 12 7	March & September	..	..
17.000	25	37/6	Indo-European	39 42	39 42	5 19 1	May and November	..	..
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	3 6 8	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs.	100 103	106 103	3 17 8	..	..	..
11,802	8	4/0	Reuter's	4½ 5½	4½ 5½	..	April and October	5	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6 per Cent.	115 120	115 120	5 0 0	" "	118½	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July	..	..
£260,900	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	2½ 3½	2 3	..	January and July	2⅞	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	97 101	97 101	7 18 5	June and December	..	..
88,321	10	6d.	West India and Panama	1 1½	1 1½	..	..	1½	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 10¾	10½ 10¾	5 11 7	May and November	10⅝	10½
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	105 108	105 108	4 12 7	June and December	108	..
64,242	15	4/6	Western and Brazilian	6½ 6¾	6¾ 6¾	5 15 7	May and November	6⅞	6½
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5¾ 6¼	5¾ 6¼	..	..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1¼ 1¾	1¼ 1¾	..	..	..	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	..	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120 125	120 125	5 12 0	May and November	..	..
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	101 104	101 104	5 15 5	March & September	102	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	2 3	2 3	..	..	..	..
22₁,₈₅₀	14/0	3½d.	Consolidated Telephone Const. & Maintenance	⅞ 1	⅞ 1	..	May and November	..	..
220,000	£1	4⅜d.	Oriental (11s. paid)	⅞ 1	⅞ 1	7 18 2	Yearly	..	..
458,867	5	2/6	National	4⅜ 4⅝	4⅜ 4⅝	5 8 1	June and December	4⅝	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14½ 15½	14½ 15½	3 17 5	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14 14½	14 15	4 0 0	" "	..	..
90,950	5	2/0	Do. 5% Non-Cumulative 3rd Pref.	5½ 5½	5½ 5½	4 10 11	.. ..	5⅝	5½
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	111 113	111 113	3 19 8	January and July	112½	..
58,000	5	1/0	United River Plate	2 2½	2 2½	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	10⅝ 11½	11 11½	..	..	11⅞	..
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½ 12¾	12½ 13	..	..	12¹⁵⁄₁₆	..
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	5 5½	.. ..	..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
8,322	£5	..	House to House Electric	1½ 2½	.. ..	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	5⅝ 5⅞	.. ..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	6 6½	.. ..	..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4⅛ 4⅛	4⅛ 4⅛	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6½ 6⅝	6½ 6⅝	..	..	..	..
111,000	5	..	London Electric Supply	.. ..	¾ 1	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	5⅞ 6½	5⅞ 6½	3 4 0	..	6½	..
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102 105	102 105	4 15 3	June and December	..	..
6,452	£10	..	Notting Hill Electric	5 6	5 6	..	..	..	..
19,980	£5	9½%	St. James' and Pall Mall	6½ 6¾	6½ 6¾	..	..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	7⅞ 8½	7⅞ 8½	4 4 10	..	..	..
59,900	5	1/6	Westminster Electric Supply (fully paid)	5 5½	5 5½	3 3 8	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/6	Brush Electrical Engineering	3½ 3½	3 3½	..	..	..	..
75,000	2	6%	Do. 6 per Cent. Preference	2⅝ 2⅝	2 2½	5 6 8	..	2⅛	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107 109	107 109	4 2 7	March & September	109	108
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref xd	4¾ 5¼	4½ 5	7 0 0	January and July	..	..
12,139	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	1⅞ 2¼	.. ..	..	..	..	..
49,900	10	12/0	Electric Construction	1½ 2	1½ 1⅝	..	..	1⅝	1½
91,195	2	10/0	Elmore's Patent Copper Depositing	¼ ½	¼ ½	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22½	21½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	1½ 2½	1½ 2½	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	4/0 5/0	3/0 4/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	2 2½	2 2½	14 11 6	May and November	2	..
37,350	12	12/0	Telegraph Construction and Maintenance	33 35	33 35	5 2 10	March and July	34½	33
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	January and July	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	¾%	City and South London Railway xd	35 37	35 37	1 13 9	May and November	..	..
37,500	£10	..	Liverpool Overhead Railway	4¾ 5	5½ 5¾	..	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 798.—Vol. XXXI. FRIDAY, SEPTEMBER 1, 1893. PRICE FOURPENCE. *Annual Subscription (U.K.), 19/6*

NOTES.

It is pretty evident from the action taken by the Municipal Corporations Association and the Glasgow Town Council, and from the frequent questioning of the Postmaster-General in the House of Commons, that the public is not disposed to allow the National Telephone Company to make too good a bargain with the Post Office. Although this cross-fire of questions has not induced the Postmaster-General to recede from the position taken up by him from the beginning, which is that he is empowered by a previous resolution of the House to settle the details of the agreement with the National Company without further ado, it has, at any rate, elicited a satisfactory assurance that when the telephone trunk wires come under the control of the Post Office no preference will be given to the messages of particular individuals. It is difficult to imagine what other answer could have been given, nevertheless the Glasgow Town Council seem to have anticipated something quite different. We trust their other fears will prove as unfounded.

The National Telephone Company, it is said, have "so negotiated the agreement that it will be found that Corporations will be placed at a vast disadvantage, and that the agreement will virtually confer on the National Company a monopoly of telephone exchange work in the country." How the Post Office, even if it desired to do so in view of future purchase of the entire system, could make the telephone monopoly more complete than it is at the present moment, by virtue of the existing Company's enterprise and the very nature of the business, we fail to see; indeed, we should have thought that with the National Company deprived of the exclusive use of the trunk wires, municipal telephony, if it is allowed, had as good a chance as it is ever likely to have.

As to the permission given to the Postmaster-General by the Telegraph Act of last year, to confer on a licencee some of the powers obtained under the Telegraph Acts, 1863 to 1889, the exercise of these powers, it must be remembered, is always to be subject to the consent of the Local Authority concerned. The reply of the Postmaster-General to the recent application of the Glasgow Town Council for a telephone licence, which will be found in our Notes columns, hints, indeed, at the grant of statutory powers to go underground. Such a grant, however, would have to be made by Act of Parliament, and if statutory powers are conferred by Parliament upon a private concern like the National Telephone Company, there need be no fear that they will be granted without some substantial concession being made to the demands of the telephoning public. That the Post Office will pay an excessive price for the trunk lines is unlikely, in view of the experience it now has of such transactions. On the other hand, no harm will be done in the long run to the public interest by paying a fair price for that which, after all, is to the Company itself a valuable adjunct to its exchange system.

The data supplied by Mr. Llewellyn Preece with regard to the placing of arc lamps, which our readers will find in another column, should prove useful to all who have to arrange for the lighting of large open spaces by means of arcs; and the series of curves which accompanies the article can be utilised to give a considerable amount of practical information regarding the character of the illumination produced by a number of arc lamps when arranged in any given manner. It may be interesting to draw attention, more fully than Mr. Ll. Preece has done, to the way in which his curves can be used. In one instance he mentions lamps placed 15ft. above the ground and at distances of 80ft. from each other. Referring to the curve for lamps placed 15ft. high we find the maximum illumination to be 1·18 candle feet, while at 40ft. from the lamp, or half-way between successive lamps, it is only 0·07 candle feet due to each arc, or 0·14 candle feet in all. The maximum illumination in this case is thus just eight times the minimum. Similarly, we find that when the lamps are 120ft. apart, the maximum illumination is 28 times the minimum, when 100ft. apart 14 times, and when 60ft. apart only three times. We deduce from Mr. Ll. Preece's numbers that on railway platforms, variations in illumination of 1 to 8 are allowable if the platforms are clear, but otherwise, to avoid heavy shadows, the change must not exceed 1 to 5, and in the neighbourhood of cranes or such structures, the variation does not exceed 1 to 2 or 1 to 3. Over the rails and cartways the change can be as much as 1 to 14, and on ordinary sidings, where little light is needed, the ratio may exceed 30 to 1.

The difficulty in measuring the diameter of a glow lamp filament by means of an ordinary micrometer, which is referred to by Mr. Ram this week, is one which also arises in micrometer measurements of the diameters of wires or sheets of very soft materials. For very exact work the arrangement

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of an electrical contact answers the purpose very well. A special form of micrometer, constructed to close the circuit of a small battery and high resistance detector when the micrometer screw makes contact with the filament, is one which we have always found to give uniformly good results. It has the advantage over the method of moving the filament to and fro, that it does not strain the filament, and the current is too minute to produce any serious heating effect. The optical method described by Mr. RAM is, when properly carried out, most convenient and expeditious. It is particularly useful for measuring the diameter of a small hole in a sheet of metal, and in any laboratory or workshop in which such measurements are necessary, it would be worth while to fit up a lamp, lens, and scale in a dark corner. When the adjustments have been made once and for all, the operation of measuring would be very simple. In the *Philosophical Magazine* for the present month Profs. DEWAR and FLEMING describe the use of a microscope for measuring the diameters of wires by optical projection.

THE Paper by Mr. FREDERICK E. BEACH on the use of cupric nitrate in the voltameter, which we print elsewhere, is worthy of comment, because it marks an advance in the method of accurate electrolytic measurement on the lines which have been laid down in *The Electrician* on former occasions. Recognition of the fact that the chemical, as distinct from the electrical, attack of the electrodes is promoted by the presence of atmospheric oxygen, has led Mr. BEACH to free his electrolyte from air by boiling, and to expose it subsequently as little as possible. The practical difficulty of working *in vacuo*, and the fact that nitrogen is not a commercial commodity like oxygen, make the device of a voltameter complete in itself, and free from the air-error—no easy task. It is worth trying whether an atmosphere of CO_2 that could be obtained from a cylinder of the gas or a common Kipp would not answer the same purpose. The purity of the cupric nitrate used is another point that might have been taken direct from our own remarks on the subject. It is unfortunate that it is less easy to obtain a pure neutral solution of the nitrate than of the sulphate, but the possibility of using a high-current density outweighs this disadvantage, which, after all, is only one to put the experimenter on his mettle, and afford, perchance, a secondary and feebler stimulus to the dealer in chemicals.

THE use of ammonium chloride in Mr. BEACH's experiments is not quite obvious. Generally speaking, mixtures of chlorides and nitrates are undesirable electrotyes on account of the mutual decomposition of the salts as soon as their respective acids are liberated. The need for neutrality is therefore the greater. Moreover, any cupric chloride formed by double decomposition would act as a solvent for the copper on its own account, with the formation of cuprous chloride. No similar effect is to be expected with pure nitrate or sulphate as the existence of cuprous nitrate and sulphate is doubtful, and in any case their stability is small. The comparison of the results of the electrolysis of copper solutions with those obtained by other methods of determining the atomic weight of copper is of value, and it is gratifying to find that the latest figures—those of Prof. RICHARDS and Mr. BEACH—show a very fair concordance, and once more confirm the value Cu = 63 when O = 16.

Now and again we hear of the efforts of some inventor to produce a continuous current, such as may be used for charging storage cells, from a simple periodic current. Various rectifying commutators have been tried, but these can only produce a humpy sort of current, the sole merit of which is that it is always in one direction; a current which must be clipped up into useful and useless portions before storage cells can be charged by it. FOURIER's theorem, the refuge and strong tower of alternate-current mathematicians, tells us, of course, that a certain combination of simple periodic currents *will* give an absolutely steady current; but theoretically, at any rate, the desired result can be obtained in a much simpler manner. All that is necessary is to be able to produce a current which shall vary as the *square* of the sine of the time, instead of, as now, as the first power. Two such currents having equal periods, but superposed in quadrature, would give a perfectly steady current such as would make a battery man's mouth water. When we were at school we were taught that the sum of the squares of the sine and cosine of an angle was constant and equal to unity. Is there no one who can invent a transformer which will utilise this simple trigonometrical fact?

Durham College of Science.—The next session of this College commences on the 25th inst. Complete courses of instruction are provided in mechanical, marine, and electrical engineering, and in naval architecture.

Cable Interruptions and Repairs.—

	Dates of Interruptions.	Date of Repair.
Falmouth—Bilbao	August 17th	August 25th.
Aden—Zanzibar	August 9th	—

Type-setting by Electricity.—For some time past the larger type in the *Electrical World* of New York has been set up by machines run by electromotors. The experience in this line has been so satisfactory that in future the smaller type will also be so set up.

Electrical Bills in Parliament.—The Royal assent was given last week to the following Bills:—London County Council (Subways); Barry Railway; City and South London Railway; Hampstead, St. Pancras, and Charing-cross Railway; Blackpool, St. Anne's, and Lytham Tramways; and Dublin Southern District Tramways.

Douglas-Laxey Electric Tramway.—On Saturday last some trials were carried out in connection with this line. The experiments were carried on under the superintendence of Dr. Edward Hopkinson. All the lines have been laid, and are almost ready for traffic, but it is not expected that much will be done this summer owing to the advanced state of the season.

Electricity in Mining.—In a Paper read by Mr. F. O. Blackwell before the Mining Engineering Sections of the International Engineering Congress, at Chicago, it was stated that there were some 300 companies in the United States engaged in mining and the kindred arts that employed electricity in their operations. Nearly all of the plants were supplied with current at 220 or 500 volts, but there were a number in which voltages of 1,000 and over were employed.

Lightning.—Dr. Mitchinson, the Lincoln District County Coroner, held an inquest last week on the body of John Tinker, a labourer in the employ of Mr. Elwes, of Broxholme, near Lincoln. On Tuesday evening last week the deceased was standing on a load of corn engaged in harvest work, when he

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was struck dead by lightning. The deceased's trousers and boots were cut as though by a blunt instrument, while his hat was picked up some distance away almost torn to pieces.

Transformer Patent Litigation in France.—The Orleans Court of Appeal has sustained the Zipernowsky-Déri patent, dated March 20, 1885, which claims the parallel arrangement of transformers and also the Zipernowsky-Déri-Blathy patent, dated April 21, 1885, covering the use of closed magnetic circuit non-polar transformers. The judgment of the Court of Appeal reverses that previously given by the Tribunal Civil de Tours, and is based entirely on the report made by three experts, MM. Fribourg, Jousselin, and de Parville.

Scarborough.—The Scarborough Electric Supply Company commenced the supply of electricity in Scarborough on Saturday last. The alternate-current system, with distribution from sub-stations, is employed. The charge for electricity is at the rate of 7d. per Board of Trade unit, with a cash discount and a sliding scale rebate amounting to 20 per cent. as a maximum for large consumers. The whole of the electric generating plant and transformers have been supplied by Messrs. C. A. Parsons and Co., of Heaton Works, Newcastle-on-Tyne.

Electric Launches.—Messrs. William Denny and Bros., of Dumbarton, have recently built for Capt. J. A. Allan, of the Allan Line, an electric launch from designs by Mr. G. L. Watson, of the firm of Mavor and Coulson. The launch is built to accompany the steam yacht "Hermione." Messrs. Mavor and Coulson have supplied all the electrical machinery. The total weight of the lauch is about 2 tons. The hull is built of cedar wood on the "double-skin" system. Carrying five persons, the launch attains and maintains a speed of 6½ miles per hour.

A Fence Telephone.—An innovation in telephonic communication has been adopted in Victoria. The idea consists of adapting the fencing wire running along the boundary as a means of transmitting sound. At the straining posts connections have been made, and at each gate or road a short overhead line has been erected clear of all traffic. At either end a small electric battery and transmitter is placed, thus bringing the stations, which are seven miles apart, within easy and convenient speaking distance. The cost of transforming the fence into a telephone line has been exceedingly small, and with the small annual cost of chemicals for the batteries, a complete, cheap, and serviceable connection is secured.

Charles' Law and the Gas Bills.—Our esteemed contemporary *Industries and Iron* points out that one effect of the recent hot weather must have been a considerable expansion of the coal gas supplied for gas lighting and other purposes. At a mean elevation of temperature of 10°C., a cubic foot of coal gas contains nearly 4 per cent. less mass; and, since the heating and lighting properties are proportional to the mass, it is so much the less valuable to a consumer. Vagaries of this sort are never indulged in by electricity. A Board of Trade unit never expands; in fact, after it has passed into the house, the current reaches the lamps, but a volt or two is dropped on the wires. Mathematicians should at once design a gas meter with an absolute thermodynamic compensator.

The Lauffen-Heilbronn Plant.—A note appears in the German technical papers relating to the progress of this work, a description of which appeared in our issue of January 27, 1893. The jumping of the light when motors are switched on has been overcome. When opened in January, 1892, 2,650 8-c.p. and 8-H.P. motors were on the mains; while at the end of May last the figures were: 8,180 8-c.p. lamps, and motors of an aggregate of 41 H.P.; and no less than 3,000 lamps and power for motors of an aggregate output of 20 H.P. were applied for. The price for light varies from 7½d. down to about 4½d., according to quantity consumed; while for motors the price is from 5d. down to 3d. per kilowatt hour. For instance, a ten-horse motor, used 12 hours per diem, costs about 9½d. per hour.

Dewsbury.—On Tuesday Mr. F. H. Tulloch conducted a Local Government Inquiry at the Town Hall, on the application of the Corporation to borrow £25,000 for a scheme of electric lighting. The Town Clerk said the question of supplying electric light had been under the consideration of the Council for three years, and they had come to the conclusion that such an installation was necessary in the interests of the town. They found that there was a demand for it, especially in the centre of the town. From the commencement they sought the best possible advice. They employed Mr. W. H. Preece to prepare specifications, and tenders for the works were invited, and had been let, after keen competition, and subject to the sanction of the Local Government Board to borrow the money. The Corporation did not propose to expend the whole of the money immediately. The Corporation had already spent large sums of money on the gasworks. There was no opposition to the scheme.

A Remarkable Copper Mine.—The Stora Kopparberget, Sweden, says *Industries and Iron*, is a remarkable copper mine in many ways. In the first place, it is said that it has been worked continuously for nearly 800 years, and that in the year 1228 it was yielding large profits to its fortunate proprietors. In the second place, there are actually figures extant, apparently carefully compiled, which claim to show the annual production of the mine from the year 1633, when 1,336 tons of copper were turned out, to the present time. According to these statistics, the Stora was in the heydey of its production in the middle of the seventeenth century, 3,455 tons of copper being extracted in the year 1650. Of late years, or rather centuries, the cupriferous deposits seem, however, to have become less productive. In 1750 only 782 tons were obtained; one hundred years later, in 1850, the figure was 843 tons; while in 1891 the quantity of copper produced was probably the lowest in a long record—271 tons.

The Post Office and the National Telephone Company.—In the House of Commons last week Mr. Maclure asked the Postmaster-General whether he could state when the agreement between the Post Office and the National Telephone Company was likely to be concluded and laid before the House, to which Mr. Arnold Morley replied that a draft was now under the consideration of the Company. Capt. Bagot asked the Postmaster-General whether, in the event of the Telephone Company's trunk lines being purchased by the Post Office, any and what arrangements were being made to safeguard the subscribers to exchanges of private or municipal concerns using the trunk lines from having their messages unduly delayed, or placed under any other disadvantages as compared with similar messages from the exchanges of the National Telephone Company. In reply, Mr. Morley stated that when the telephone trunk lines came under the entire control of the Post Office, their use would be subject to the usual regulations which forbade any favour or priority being given to particular persons.

Opening of the Kelvinside Electric Lighting Station.—The electric lighting station of the Kelvinside Electricity Company, Glasgow, was formally opened on Monday, at noon. Provision is made in the complete station for ten 150-H.P. boilers, and two of these are in position and under steam. The foundations for six engines and dynamos of 120 H.P. each are already in. Two engines of the Willans type are placed and are running, as are also two dynamos of the Goolden make, which work at 400 revolutions per minute. Parallel with the engine and dynamo room there is the battery room, which contains 60 E.P.S. cells capable of a maximum discharge of 1,200 amperes. Underneath the station proper there is a subway which gives access to the conductors between the dynamos and the switchboard and to the end of the feeder mains. These mains, which are of the lead-covered armoured type, are so arranged as to work on the two-wire system, to begin with. Houses are already wired for a total of some 1,500 lamps of 16 c.p. each. The works have been designed by, and carried out under the superintendence of, Mr. John M. M. Munro, of the firm of Anderson and Munro, Glasgow; and Messrs. Sharp and Kent have been the contractors for the whole work.

The "Cartesian" Ammeter.—There is no anachronism; this instrument was not invented by Descartes, but is named after the scientific toy known as the Cartesian diver, upon the pneumatic principle of which it is operated. In the toy a hollow glass vessel, more or less resembling a human figure, but

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with a bulbous and highly-developed head, and with a couple of holes in its feet, is partly filled with water and immersed in a glass cylinder nearly filled with water. The top of the cylinder is covered with a stretched membrane. Normally, the diver, as the figure is called, is lighter than water; but, on pressing in the diaphragm, the air in the diver is compressed, water passes through his toe-holes and accumulates in his bulbous head, making him slowly sink. Mr. J. G. Lorrain has adapted this toy to current measurement for lecture illustration. The bulbous head is replaced by a hollow graduated stem, and a rigid air-tight plug takes the place of the elastic diaphragm. On sending a current through a resistance coil placed in the upper part of the cylinder the pressure of the air in this part increases, and water enters the graduated stem and sinks it to a point which depends on the current strength. Mr. Lorrain says there is no patent on this instrument, and that the world is welcome to it. But, unfortunately, the temperature errors are too great for the world to be likely to use the instrument where any exactitude is required.

The Queenston-Chippewa Electric Railway.—The *Electrical Engineer* of New York for August 9th contains an interesting account from the pen of Mr. T. C. Martin of the latest Canadian electric railway, that running from the head of Lake Ontario along the Niagara River to the end of Lake Erie, a distance of about 13 miles, of which no less than 37 per cent. is on curve. "The first thing that strikes an observer," says Mr. Martin, "is the British solidity and massiveness of the construction. It is regular steam railroad work and a little more." Part of the line is equipped with tubular steel poles, the rest with cedar poles. The trolly wire is No. 00 B.W.G. hard-drawn copper. The rolling-stock consists of 16 motor and 18 trail cars, the motor cars each having two 50-H.P. motors. The line passes over three heavy bridges and a trestle bridge 500ft. long and 150ft. high. The power is obtained from the Niagara River just above the falls, water being supplied under a head of 62ft. to two 1,000-H.P. Leffel turbines, which are coupled to a set of 200-H.P. four-pole generators. There is a supplementary steam-power generating station at the other end of the line containing two 100-H.P. generators. This plant is only intended to be used in the busy summer months, when excursion parties of 1,000 to 1,500 persons are constantly being landed at Queenston from the Toronto steamers, and require to be taken up the mile and a-half of 5 per cent. to 6 per cent. gradient.

American Indians and Electricity.—The modern marvels of electricity, says the *Electrical Review* of New York, have not been appreciated by the Indians who have done their best to stop their importation. A telephone line had been laid down by the Government between La Paz (Bolivia) and Lake Titicaca, 45 miles away, but the Indians got the idea that the much-sounding talk of the white man that could be heard thus far would disturb the long sleep of their ancestors, and they stole the wire and used the poles as firewood. These were replaced, but at last the whole line was ruthlessly torn down, and the Government was compelled to abandon it. The Indians next turned their attention to the electric light plant, which was being installed here, and awaited an opportunity of destroying it. After the plant had been in operation a few nights there was an eclipse of the moon. The Indians believed that the electric light was absorbing or swallowing the moon, and, gathering in a body, moved upon the plant to destroy it. It was saved only by the intervention of a large body of troops. The Government next day selected several representative Indians, took them to the power house and shocked them severely, then took them out along the line and shocked them again with the wires. After this they informed them that the electric light was an evil spirit, and that they had better leave it alone. The Indians were convinced that they could not fight against an enemy that could twist their muscles into kinks when miles away, and there has been no further trouble.

Reinforcing Steam Pipes.—It has been proposed more than once, says *Engineering*, to reinforce copper steam pipes by shrinking steel rings around them. Theory, however, shows that unless these rings are very closely spaced the pipe may actually be weakened by their presence, and the correctness of this view was borne out by a series of careful experiments made on this point by Commodore George W. Melville, chief of the Engineering Bureau of the United States Navy. Comparative tests by him between plain and reinforced pipes showed both to fail at practically the same pressure. In the Italian Navy the plan of reinforcing the pipes with wire has definitely been adopted, and is described by Mr. Nabor Soliani in the *Revista Marittima*. The practice is to serve the tubes over with one or more layers of closely laid metal wire, wound on under tension. Up to about 8in. in diameter drawn tubes are used without reinforcement. Above this diameter, however, the tubes are made out of copper sheets by brazing in the usual way, and are then wrapped round with a close spiral of copper or Delta metal wire. This method of reinforcement is only considered applicable to straight tubes, and, accordingly, these only are used, gun-metal castings being adopted at the elbows and bends. The wire is of sufficient section to carry the full steam pressure independently of the strength of the tube; the latter is, however, made strong enough to stand the usual hydraulic test before the wire is put on. The reinforcement is made up with two or three independent spirals, so that if one wire breaks the tube is still held up to its work by the others. The ends of these separate spirals are fixed independently to the flanges. The tension at which the wire is wound on is about $1\frac{1}{2}$ tons per square inch.

The Telephones at Glasgow.—The following is the reply of the Postmaster-General to the application of the Glasgow Corporation for a telephone licence:—"Sir, I am directed by the Postmaster-General to acknowledge receipt of your letter of the 12th instant, enclosing an application from the Lord Provost, Magistrates, and Council of Glasgow for a licence to establish a telephone exchange within that city. The Postmaster-General observes that the application refers to a recommendation of the recent Joint Committee on Electric Powers, and he thinks it right to inform you that he has received a communication on the subject from the Association of Municipal Corporations. The question whether measures shall be taken, and if so what measures, to give effect to this recommendation of the Joint Committee must engage the very careful consideration of Her Majesty's Government; and the Association has been informed that no final step will be taken until they have been afforded an opportunity of expressing their views. In these circumstances, and in view of the intimate relation between the question of fresh licences for telephone exchange business, and that of statutory powers for laying telephone wires underground, the Postmaster-General does not feel that he can at present arrive at any decision on the application enclosed in your letter."—The deputation of the Glasgow Town Council which came up to London in connection with the municipal telephone scheme and cognate matters, was received privately by the Postmaster-General on Wednesday last. Sir Charles Cameron, M.P., introduced the deputation, who asked that the Corporation should be allowed a licence to start a municipal telephone exchange. Mr. Provand, M.P., supported the views of the deputation. The Postmaster-General, in reply, said he would come to no decision adverse to municipal enterprise. The Government would not at all interfere with the freedom of municipal enterprise with regard to any matters it could legitimately control for the public interest. The telephone, however, was not a part of municipal business, but belonged to the telegraph system, which was conducted by the State. It was not confined to the municipal area like water, gas, or tramway works. In continuance of the policy of the late Government, he was now engaged in purchasing the trunk lines of the telephone system, and until that was completed it was impossible to consider the question raised by the present application. The movement might possibly develop into the Government's taking over their entire management, but any step taken in advance in local districts would complicate matters. He was strongly in favour of further powers being given to the municipalities to manage affairs which were strictly municipal, but he could not enter into further details on the question raised by the deputation until the agreement as to the trunk telephone lines had been finally settled.

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ELECTRIC MOTIVE POWER.*

BY ALBION T. SNELL.

(*Continued from page 335.*)

Parallel Working.

The term "parallel" is applicable to a number of systems of distribution, in all of which the current is divided into branch circuits, and the energy is supplied to the distributing mains at approximately constant pressure. The conducting circuit may be complex, and as it will be necessary to make frequent reference to its various parts, it will simplify matters to define the terms used in these pages.

The feeding mains, or simply the *feeders*, are the large conductors which carry (high or low pressure) current to a central point of distribution, or to the nearest motor, in a simple parallel case. They may be long or short, according to circumstances, but since their function is that of carriers only, they relate to the transmission part of the problem, and are distinct from the distributing net work of mains. Feeders, therefore, are never tapped by branch connections.

The distributing mains, or briefly the *distributors*, are designed to carry the current from a centre of distribution, *i.e.*, the end of a feeder, to the service mains which supply each consumer. They will vary in section and length according to the area to be served, and may form simple radial lines from the distributing station, or in some cases a complicated net work looped at the extremities by ring mains. Distributors may be tapped at any point in their length to supply current to consumers.

The *Service mains* are the pairs of conductors connecting a motor or bank of motors (or lamps) to a distributor.

The parallel systems suitable for power work are :—

(*a*) Simple parallel, reverse parallel.
(*b*) Feeder system.
(*c*) Three-wire system.
(*d*) Multiple-wire feeder system with regulators.

Inspecting Figs. 26 to 34, which illustrate diagrammatically the several arrangements, it will be seen that the condition of constant pressure between the distributors is common to all, and that since the energy at any point is equal to the product ei_n, it follows that variations of load have to be made by changing the current of the particular motor (or lamps). This is exactly the converse of the series system of supply. The immediate effect of the variable current is to cause the loss in the mains (feeders and distributors) to vary with the square root of the load. This is an advantage, since the line loss is then in proportion to the useful effect; but it also causes the pressure at different parts of the line to vary inversely as the load, which is exactly the opposite of what is required.

The line loss is expressed in watts by :—
$i^2 R + i_1^2 R_1 + i^2_2 R_2 \ldots + i_n^2 R_n$, where i, i_1, $i_2 \ldots i_n$ are the several currents in different parts of the circuit, of which the respective resistances are R, R_1, $R_2 \ldots R_n$. And the fall of pressure in volts on the several sections is given by iR, $i_1 R_1$, $i_2 R_2 \ldots i_n R_n$.

The aim, then, in a parallel system will be to compensate for the drop in the feeders, and to keep the pressure constant at the centre of distribution. There will remain a slight fall of pressure uncompensated for between this centre and the points of supply, *i.e.*, the motor terminals. But this is practically unavoidable, and in most cases can be made so small as to give no trouble if sufficient copper be put into the distributors and service mains; for then the product iR becomes so small, even at full load, as to be insignificant. The weak point in simple parallel working is that the pressure is limited by the voltage of the smallest motor, or that of the lamps run in parallel with the motors. In lighting circuits, where incandescent lamps requiring about 100 volts are mainly used, the pressure at the centre of distribution is necessarily about 100 volts, although at the station it must be higher by an amount determined by the resistance of the conductors. In power circuits where lighting is of secondary importance the pressure on the distributors may be, say, from 300 to 500 volts: and lamps may be coupled in series to make up the required voltage. Thus three incandescent lamps of 100 volts each may be coupled in series across a pair of mains having a pressure between them of 300 volts; and, similarly, five 100-volt lamps may be placed across a 500-volt circuit (*see* Fig. 26).

Raising the pressure of distribution permits a reduction in the weight of the copper, but at the same time introduces complications which require careful attention.

In the first place, consider a constant length of conductor, with constant power at supply station, and let the pressure of supply be varied. As before :—

a = area of conductor.

R = resistance of conductor = $\frac{l}{a}k$, where l = the length of conductor and k is a constant.

e = pressure of distribution.

Then we have

$i^2 R$ = line loss; $\frac{i}{a}$ = the current density.

iR = drop of pressure in volts.

ei = the power transmitted = a constant.

Now assume that the pressure is doubled so that it may be represented by $2e$, then the current will be $\frac{i}{2}$, since the power is to be the same as before.

The line loss will now be $\left(\frac{i}{2}\right)^2 R = \frac{i^2 R}{4}$, *i.e.*, only one-fourth as great; and the drop of pressure will be $\frac{i}{2}R$, or one-half. The section of the conductor may, therefore, be safely reduced.

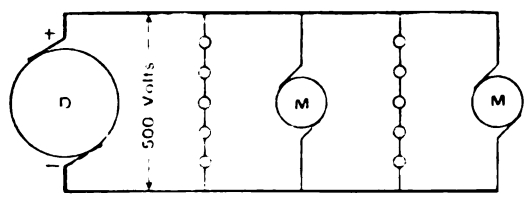

FIG. 26.

There are two cases of importance in practice.

Firstly, when it is essential to keep the *line loss*, $i^2 R$, constant. In this case the area of the new conductor need only be one-fourth of the old one, and will have four times the resistance; or the line loss will be $\left(\frac{i}{2}\right)^2 4R = i^2 R$, the same as before; and the line drop will be $\frac{i}{2}4R = 2iR$, or the same *percentage* drop as before, which is equivalent to saying that *the line loss remains constant when the percentage of the line drop is kept the same for variations of supply pressure.* It must be noticed that the current density has been doubled, for it is now equal to $\frac{i}{2} \div \frac{a}{4} = 2\frac{i}{a}$.

Secondly, when it is necessary to keep the *line drop*, iR, constant. This can be accomplished by using a conductor of half the area and twice the resistance, for then the drop $= \frac{i}{2}2R = iR$, as in the first case. And the line loss will be $\left(\frac{i}{2}\right)^2 2R = \frac{i^2 R}{2}$, or only one-half as great as before. Therefore the economic current ratio, $\frac{i}{a}$, is also constant, for both current and area of conductors are halved. Or, generally when *the current density is kept constant, the line drop is also constant for variations of supply pressure.*

The latter of these two cases is, perhaps, of the most importance in relation to the feeders, for in relation to them the economic current density is the chief consideration, and the ratio $\frac{i}{a}$ should have the same value in both long and short feeders, the different drops of pressure being compensated at the supply station. Strictly speaking, on the score of economy,

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the same considerations should determine the gauges of the distributors, but frequently the fall of pressure will be the only criterion, and then the conditions suggested in the first case will obtain, viz., a constant percentage of drop.

If the current density be settled, as it should be, in accordance with the economic law, the current varies as the area of the conductor, $\left(\text{or, } \frac{i}{a}\right)$, and the drop, i R, is simply proportional to the length of the conductor. For each pressure of supply and current density, then, there will be a definite distance through which the power can be transmitted for a given drop. This distance includes the feeders, the distributors, and the service mains, if the drop be measured from the dynamo to the motor terminals; but in most cases it will be convenient to consider the three drops separately.

The fall of pressure for any section may be determined in the following manner if the current density, $\frac{i}{a}$, be fixed :—

$$i\,\mathrm{R} = i\frac{l}{a}k. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

And if l be expressed in yards and a in square inches (the most convenient and practical units for these calculations), then k will be the numerical value of the resistance of one yard of copper of one square inch in cross section, and will be approximately equal to $\frac{25{\cdot}6}{10^6}$ for ordinary commercial samples. Therefore

$$i\,\mathrm{R} = l\frac{i}{a}\cdot\frac{25{\cdot}6}{10^6}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (24)$$

From this equation, if we know the drop, we can find the possible length of conductor; and if l be determined, then the corresponding drop can be estimated.

It will sometimes be more convenient to estimate the drop in terms of the length of the section (measured along the conductors) rather than in terms of the length of conductor. To do this it is only necessary to put l, equal to the length of the section, and multiply the right hand member by 2; thus

$$i\,\mathrm{R} = 2\,l_1\frac{i}{a}\frac{25{\cdot}6}{10^6}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

If $i\,\mathrm{R} = 1$, then l_1 will give the number of yards per volt drop for the particular value of the economic ratio $\frac{i}{a}$.

The following table has been prepared in order to give the reader a graphic idea of the effect on the drop for different pressures and distances, with various current densities :—

Table I.—*Two Wire Mains. Drop of 1 per cent.*

Current density in amperes per square inch.	Distance in yards from the central station for a drop of 1 per cent. at the following pressures of supply.			
	100 v.	200 v.	500 v.	1,000 v.
1,000	19·5	39·0	97·5	195·0
900	21·75	43·5	108·75	218·0
800	24·5	49·0	122·5	245·0
700	27·75	55·5	138·75	278·0
600	32·5	65·0	162·5	325·0
500	39·0	78·0	175·0	390·0
400	49·0	98·0	245·0	490·0
300	65·25	131·5	316·0	653·0

To find the distance for a drop of n per cent., multiply the distance in the columns against the given pressure and current density by n.

In the above table the percentage of drop in the line and the current density are kept constant for pressure variations, both current and area of the copper varying inversely with the pressure of supply. The line loss, $i_m{}^2$ R, will remain constant under these conditions.

(To be continued.)

The Measurement of Insulation Resistance.—A prize of 2,000fr. is offered by the Société d'Encouragement, for an apparatus or industrial process for quickly measuring the insulation resistance of the various parts of an electrical plant while in operation. The prize will be awarded in 1895.

THE PLACING OF ARC LAMPS.

BY LLEWELLYN PREECE.

Although it can hardly be said that the Midland Railway has any fixed rules with respect to the placing of arc lamps, as so much depends on the local arrangements, &c., each place to be lighted, there is a standard of illumination to which is adhered to as nearly as possible, and there are, therefore, fixed outside limits for the distances which lamps may be placed apart. A few notes on these limits may be of interest to those engaged on similar work.

Arc lighting on the Midland Railway is carried out principally in goods sheds, goods yards, and passenger stations. In goods sheds there are the platforms (or decks, as they are usually termed), the cartways, and the metal roads to be lighted. For the decks the limit is 70ft. The standard of illumination is that a man standing anywhere shall be able to read with ease an ordinary label; this is obtained with lamps at distances of 80ft. over a clear platform, but owing to the generally crowded condition of a goods shed deck, 70ft. is the maximum distance at which lamps can be placed without heavy shadows being thrown. In practice, however, it is the distance apart of the cranes—of which there are always a number—which finally determines the distance of the lamps. These cranes, which have as a rule a working radius of 16ft., are placed apart at distances varying from 40ft. to 60ft., and it is found that the best illumination and safest positions for the arc lamps is down the centre of the platform and midway between each crane and the next. Where the platforms are very broad and two rows of cranes are required, it is best to have two rows also of lamps, and as before, midway between the cranes. Over cartways and metal roads, the amount of illumination required is not so great, and the lamps may well be placed 100ft. apart, except in cases where unloading is carried on direct from the trucks to carts, when, as sufficient illumination is required for reading labels easily, 80ft. should be the limit. The distance apart of the rows of lamps depends to a great extent on the arrangement of the decks, roads, and cartways, and also on the size and distances apart of the pillars which carry the roof. 80ft. may be taken as about the average, however.

The height of the lamps above the decks has, after considerable experimenting been fixed at 14ft. If brought any lower, complaints are made that the light is too dazzling. Over the roads and cartways 18ft. is usual.

Goods yards are made up of points, sidings, unloading roads, and approach roads. For "nests" of points and unloading roads it is found that 100ft. to 110ft. give the best results, the lamps being always 20ft. in height. In the case of single points we find it best to place lamps also, as it is at such places lights are chiefly required in a yard. At the same time it is very inadvisable to leave gaps of a greater length than 250ft. between any two lamps.

With regard to the ordinary sidings, no light is required except with sidings used for marshalling trains at night, in which case the lamps may be 120ft. apart. Approach roads have lamps usually from 120ft. to 150ft. apart, this giving ample illumination. Lamps at a height of 25ft. would give the best results in this last case, but on the Midland the lights are fixed at 20ft., as this enables us to have only one size pillar.

With regard to passenger stations on main line platforms the limit is 80ft., on local platforms 90ft. The actual distances, however, depend on the spaces between the girders carrying the roof, as it is the invariable practice to hang the lamps from the girders. So that in some cases lamps are placed considerably nearer. At St. Pancras, for instance, the girders being 30ft. apart, the lamps on the main platforms are placed at distances of 60ft. In the booking halls the position and the distances of the lamps are somewhat subject to appearances, and 60ft. is about the outside limit. The height is always 14ft., the same as in goods sheds.

I have supposed throughout that we have been dealing with the 500-watt lamp, or nominal 2,000 c.p. But in several places the Company uses the 350 watt lamp—nominal 1,200 c.p., in which cases the limits are reduced by 10ft. or 15ft. Opalescent

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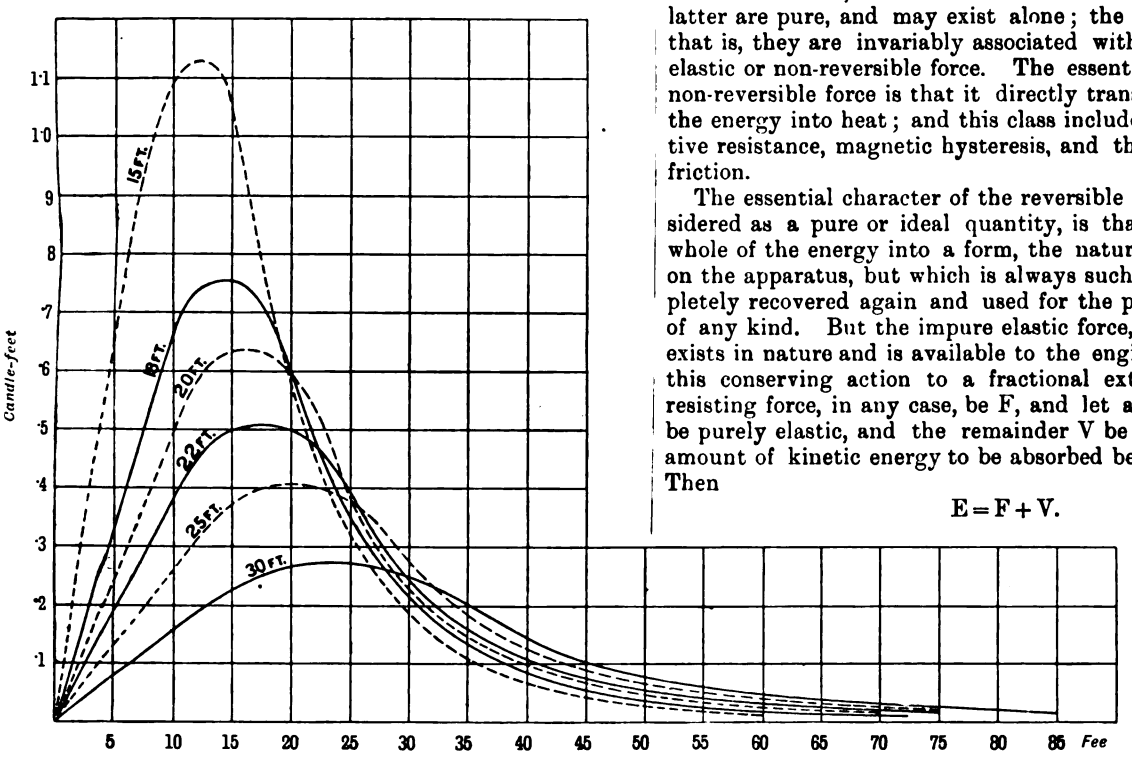
bes are used in goods sheds and passenger stations, clear bes in yards and approach roads.

The accompanying diagram is a series of curves showing the minating power of a 1,000-c.p. arc lamp at various heights. In A. P. Trotter's Paper on "The Distribution and Measurement Illumination," read before the Institution of Civil Engineers May, 1892, it is shown that the illumination of an arc lamp ries as the fourth power of the cosine of the angle of incnce ($\cos^4 \theta$) for angles greater than 45deg., and also that the umination at about this angle is at the maximum. The rves are arrived at from this information, being obtained as llows:—Assuming the light of the lamp to be 1,000 candle wer, the illumination underneath the lamp, ignoring the wer carbon, would be 1,000 candle feet divided by the uare of the height. This may be taken as the value illumination with θ at 0°. The curve, however, only starts



45deg, the value $\cos^4 \theta$ being 0·25. The actual maximum therefore 0·25 the supposed value under the lamp. Startg from this point the curves are the various values of $\cos^4\theta$ ivided into the supposed value of illumination under lamp. he ordinate is marked out in feet instead of the angles of cidence, being simpler for practical work. The scales both r the feet on the abscissa, and candle feet on the ordinate are ite arbitrary.

The practical use of this diagram is to enable designers for e arrangements (as regards height and distance apart) of arc mps to obtain some idea of the resulting illumination that ll be obtained with lamps fixed at various heights and disnces, or having been given a minimum and maximum illumiation, to so arrange their lamps that the desired result may obtained.

THE ABSORPTION OF ENERGY.

Although a supply of energy is indispensable to animate stence on this globe, and notwithstanding the care by which sources of nature are directed by engineers for the use and venience of man, there is, besides a huge waste of energy, a tinual need for dissipating it. Surplus energy is in most, if in all, cases kinetic, as the character of potential energy is h that its non-dissipation is not liable to exert prejudicial ions. Some examples of the intentional dissipation of surplus energy occur in the shading of a light of brilliance, by an obscured globe or a window blind, the use of a fire screen, of a Prony brake, a resistance coil with arc lamps in parallel, and a carriage brake. In some of these there is no attempt at conservation or diversion of the redundant energy, but in others, utilisation is possible. There are two general kinds of absorption: 1st, where the surplus energy is directly dissipated as heat; 2nd, where it is made to perform some useful work, or is stored in some efficient accumulator before being ultimately spent as heat. The energy of every mechanical contrivance finally escapes as unavailable radiation into space; and all that man can do is to hinder its dissipation and make it do some useful thing before it leaves him for ever. This is called useful work.

In general, there are two forms of resisting force which may be opposed to a quantity of kinetic energy; namely, reversible or elastic forces, and non-reversible or viscous forces. The latter are pure, and may exist alone; the former are impure, that is, they are invariably associated with an element of inelastic or non-reversible force. The essential character of the non-reversible force is that it directly transforms the whole of the energy into heat; and this class includes electrical conductive resistance, magnetic hysteresis, and the various forms of friction.

The essential character of the reversible or elastic force, considered as a pure or ideal quantity, is that it transforms the whole of the energy into a form, the nature of which depends on the apparatus, but which is always such that it may be completely recovered again and used for the performance of work of any kind. But the impure elastic force, such as that which exists in nature and is available to the engineer, only performs this conserving action to a fractional extent. Let the total resisting force, in any case, be F, and let a portion, E, of this be purely elastic, and the remainder V be viscous, and let the amount of kinetic energy to be absorbed be represented by K. Then

$$E = F + V.$$

This total energy will be absorbed in a time

$$t = \sqrt{\frac{2K}{a(F+V)}}.$$

Where a is the acceleration (negative) or the ratio of the resisting force to the reduced inertia at its point of application. Calling this latter quantity I, we get the general expression

$$t = \sqrt{\frac{2KI}{(F+V)^2}}.$$

And the distance or linear movement of the point of application of E will be

$$s = \frac{K}{F+V}.$$

During this action, represented by the above equations, the energy K has been transformed into a dissipated amount equal to Fs and a stored amount Vs, so that the efficiency of the absorption—assuming it is desired not to dissipate energy—is the ratio of the elastic to the total force. This fact is at the basis of all storage and usefully-absorptive apparatus. Among the class of practical reversible forces for absorbing energy we may include: the actions which arise in an ideal secondary battery, there being a purely elastic reaction called a chemical electromotive force, and an inelastic reaction called the internal resistance; the thermo-electric effects at the junctions of two dissimilar metals; the self-induction effect of an electromagnetic circuit; the elasticity of a coiled-up spring, or of compressed gases; and the elevation of water or other masses to a distance above any level to which they may return.

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THE USE OF CUPRIC NITRATE IN THE VOLTAMETER AND THE ELECTRO-CHEMICAL EQUIVALENT OF COPPER.*

BY FREDERICK E. BEACH.

Among the voltameters in common use the silver voltameter gives results of a very high degree of accuracy, but is not conveniently used except for comparatively small currents. On the other hand, the copper voltameter from the cheapness of materials and facility of manipulation finds convenient employment in the laboratory. As ordinarily used with the sulphate of copper, it is subject to certain irregularities due to the attack of the copper by the solution under some conditions, and the oxidation of the metal in others. For these reasons as well as for the fact that excellent deposits of metal are obtained from the nitrate of copper, even with great current densities, it seemed probable that this salt could be successfully used in the voltameter. The object of this Paper is to show that cupric nitrate has some marked advantages over the sulphate. For purposes of comparison the results and conclusions of different experiments will be passed in review.

Gore† expresses the opinion that two independent forces act in the solution, one chemical the other electro-chemical. The action of the former is assisted by a rise of temperature. The loss of the anode is greater than the gain of the cathode, but the chemical corrosion of the anode is less than that of a separate piece of copper without a current. The purely chemical corrosion of the cathode is more than that of the anode. The addition of any considerable amount of sulphuric acid had the effect of diminishing the weight of copper deposited.

Hammerl‡ as the result of a detailed investigation comes to the following conclusions :—

I. No change in the quantity of the deposit was observed when a blank platinum surface was substituted for one which had been covered with a deposit of copper.

II. The change of concentration of the solution caused by the psssage of the current and the polarisation dependent on it cannot be satisfactorily prevented by agitation. In boiling to agitate the fluid the deposit oxidises almost completely to Cu O, and partially indeed between 40° and 60°C.

III. The highest allowable current strength is seven amperes per square decimeter. The distance between the plates should not be less than 1·5 cm.

Gray§ finds that the highest current-density desirable is one ampere to 50 square centimetres $\left(=0{\cdot}02\ \frac{\text{amp.}}{\text{cm.}^2}\right)$. He obtains the ratio $\frac{Cu}{2Ag}=0{\cdot}2940$, and for the electro-chemical equivalent of copper $0{\cdot}0003287\ \frac{\text{gm.}}{\text{amp. sec.}}$ when silver is taken as 0·001118. He remarks "This would indicate a value not diffesing much from 0·0003290." He does not find as did Gore, that loss by chemical action is less when the current is flowing than when it is not. Copper was dissolved in the sulphate at the rate of $0{\cdot}02\ \frac{\text{mgm.}}{\text{cm}^2.\ \text{hr.}}$. Addition of sulphuric acid seemed to retard the loss when the density of the solution was between 1·1 and 1·15.

Gray‖ using a density of the sulphate solution of 1·15 to 1·18 with one per cent free sulphuric acid found that the equivalent depended on temperature and current density in a manner which is exhibited by the following table. The factor 10^{-7} has been omitted.

Area of cathode in sq. cm. per ampere.	Temperature.				
	2°C.	12°C.	23°C.	28°C.	35°C.
50	3,288	3,287	3,286	3,286	3,282
100	3,288	3,284	3,283	3,281	3,274
150	3,287	3,281	3,280	3,278	3,267
200	3,285	3,279	3,277	3,274	3,259
250	3,283	3,278	3,275	3,268	3,252
300	3,282	3,278	3,272	3,262	3,245

Vanni¶ found that a solution of copper sulphate of density 1·12 with 1 per cent. of free sulphuric acid dissolved copper, while a solution neutralised with copper hydrate gave an excess. Combining a liter of the normal solution with a half gram of that containing 1 per cent. of the acid, neither a gain nor loss could be observed in the weight of a piece of copper immersed in it.

The mean of six experiments with such a solution showed $\frac{Cu}{2Ag}=0{\cdot}2938$, whence Cu equivalent $=0{\cdot}0003284$ with a current-density between 0·011 and 0·002.

Cintolesi† observed that the solution of a copper plate in copper sulphate depends on the time and the current strength. In vacuo the amount of copper dissolved is less than in air. Oxygen was believed to have an essential influence on the phenomenon.

Shaw* using copper sulphate, and a current density above $0{\cdot}025\ \frac{\text{amp.}}{\text{cm}^2}$, found as a mean of fifteen experiments that the ratio of $\frac{2Ag}{Cu}$ was 3·39983 or Cu equiv. $=0{\cdot}00032886$.

It thus appears that the behaviour of copper sulphate had been thoroughly studied ; but no quantitative determination had been made with the nitrate, as far as the writer knows, although it had been stated by Smee and others that the nitrate would bear a much greater current density than the sulphate.

The apparatus used in the experiments presently to be considered may be briefly described as follows :—The cathode was made from a piece of electrolytic copper, about 2mm. thick, by bending it so as to form three sides of a rectangle. This was immersed in copper nitrate contained in a glass beaker. The anode was usually a thin sheet of platinum, though copper was occasionally substituted for it. The former was much preferred on account of the ease with which the copper is removed by dipping in nitric acid. After rinsing with water the platinum electrode may be dried by heating to redness in a Bunsen flame. The current was measured by the silver voltameter when small, and Thomson balance in a few instances when the total current was large. The value of the equivalent of silver used in calculating the numbers hereafter given was 0·0011181, the mean of the value 0·0011183 found by Kohlrausch† and 0·00111794 the one given by Rayleigh.‡

It was found, early in the course of the work, that when the nitrate solution was freshly prepared it had a tendency to dissolve copper, and that this tendency, which was due to the solvent action of the solution itself or the presence of a small quantity of free acid, decreased after the copper electrode had been kept in the solution a sufficient length of time, and that this latter effect seemed to be facilitated by the passage of the current. On the other hand another difficulty to be contended with was the oxidation of the copper deposited after the solution had been used too many times or the current was pushed too far, causing in many cases a darkening, or even perceptible blackening, of the metal. It was, however, discovered that the blackening due to oxidation could be prevented by the addition of a small amount of ammonium chloride.

Experiments were now made, in which the current density was varied through a considerable range, with results which are given in the following table :—

No.	Solution.	Current-density amperes / cm²	Cu. Eq. · 10
1	$Cu(NO_3)_2$ nearly neutral without NH_4Cl	0·035	3291
2		0·065	3291
3		0·144	3293
4		0·024	3293
5		0·83	3305
6	$Cu(NO_3)_2$ with NH_4Cl	0·114	3290
7		0·074	3297
8		0·076	3298
9		0·094	3299
10		0·019	3290
11		0·048	3297

These values show no dependence on the current-density except No. 5, where the large value of the equivalent is best accounted for by oxidation caused by the excessive current. This deposit was badly fringed at the edge, and easily detached. Nos. 1—5 made by repeated use of the same solution, show more uniformity than was at any other time obtained from a solution without ammonium chloride present. Attention may be called to what appears to be evidence of the neutralisation of the solvent effect of the nitrate on the copper in the gradual but not always regular increase in the values obtained from the same solution in successive experiments.

* From the *American Journal of Science*.
† *Nature*, March 16, 1882.
‡ *Wien. Ber.*, (2), lxxxviii, pp. 273—294.
§ *Phil. Mag.*, xxii, p. 289, 1886.
‖ *Phil. Mag.*, xxv., p. 179, 1888. ¶ *Wied. Annal.*, X., p. 214, 1891.

* *Beiblätter*, XVI., p. 80, 1892.
† *Phil. Mag.*, XXIII., p. 138. 1887. § *Wied. Annal.*, XXVII., p. 57. 1886.
‡ *Phil. Trans.*, p. 439, 1884.

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Having now obtained a fair control of both the tendency to oxidation and solution, experiments were next undertaken with a view to determining the value of the electro-chemical equivalent. With the exception of Nos. 1—5 already quoted, the solutions used in obtaining the numbers given in the First Series were alike in that they were neutral with respect to the copper, and contained NH_4Cl.

No.	First series. Equivalent × 10^7.	No.	Second series. Equivalent × 10^7.
1	3291	33	3294
2	3291	34	3296
3	3293	35	3290
4	3293	36	3293
5	[3305]	37	3295
12	3296	38	3294
13	3297	39	3296
14	[3305]	40	3298
15	3293	41	3293
16	3294	42	3291
17	3296	43	3292
18	3294	44	3302
19	3292	45	3296
20	3300	46	3293
21	3299	47	3294
22	3299	48	3291
23	3291	49	3292
24	3295	50	3293
25	3294	51	3292
26	3292	52	3293
27	3300	53	3292
28	3292	54	3291
29	3296	55	3298
30	3301		
31	3291		
32	3295		

The mean of the First Series, including Nos. 5 and 14, is $3295{\cdot}6 \pm 0{\cdot}54$. If these experiments be excluded we get $3294{\cdot}8 \pm 0{\cdot}43$.

Neutralisation of the solution in the experiments described had been effected by repeated use. A readier method which suggested itself was to boil the nitrate in order to expel the air, allowing a piece of clean copper to stand in the hot solution until its solvent action had been exhausted. Such solutions were prepared and after the addition of a small amount of NH_4Cl yielded values tabulated in the Second Series, the mean of which is $3293{\cdot}9 \pm 0{\cdot}4$.

In some cases the solutions employed were used many times so that the tests to which the nitrate has been subjected are in this respect particularly severe. There is good reason for supposing that the numbers would have been more consistent if a fresh solution had been used each time.

It is natural to inquire how the values found agree with the equivalent calculated from the atomic weight of copper.

The last-named quantity has been investigated with great care by T. W. Richards* with the following result :—

If silver be taken as 108·00, oxygen as 16·000 and bromine 80·007.

From Cu : 2Ag he finds Cu = 63·640
Cu : (2AgBr) Cu = 63·648
$CuBr_2$: 2Ag Cu = 63·643

Cu = 63·644

whence we get $\frac{Cu}{2Ag} = 0{\cdot}29465$

and Cu Equivalent = 0·00032944
when silver is taken = 0·0011181.

Hence the value here found is substantially in accord with Richards'. In making this comparison it must be borne in mind that the present investigation was not undertaken for the purpose of finding the equivalent of copper but to determine how well the nitrate would serve as the electrolyte in the copper voltameter, and that, too, throughout a considerable range of conditions. That these conditions when working with such a sensitive metal as copper were sometimes unfavourable to uniformity of result may be sufficient to explain the amount of variation from the mean. The probable error of a single observation in the Second Series is $\pm 1{\cdot}9$.

Further experiments were tried to determine the effect of variations in the temperature. Here again it is to be remembered that the solutions were not freshly prepared. A considerable change of temperature either up or down seemed to favour oxidation, but more particularly the latter, probably on account of the increase in concentration of the salt when cooled. Still even this was in great measure prevented by a sufficient addition of the ammonium chloride.

No.	Solution.	Temperature.	Equivalent × 10^7.
56	$Cu(NO_3)_2$ with NH_4Cl	19°	3296
57	Same.	6	3297
58	Same.	34	3292
59	Same.	29	3321
60	Another solution.	18	3291
61	Same.	36	3297
62	Same.	37	3296
63	Same.	6	3313
64	Same.	10	3307
65	A different solution.	40	3291
66	Same.	10	3292

From these experiments we may conclude that a moderate change of temperature is not a critical matter.

The First and Second Series were made at the temperature of the room which did not vary much from 19°C.

The following method is recommended for the preparation of the solution : Dissolve copper nitrate, the purest obtainable, in distilled water. Boil for a short time to expel the air and keep at a temperature of 100°C. for an hour or two in the presence of bright metallic copper in order to completely neutralise the solution. When ready for use it should have a density of about 1·53. Add a saturated solution of NH_4Cl at about the rate of one drop to 100cc of the nitrate. Just the proper amount of ammonium chloride it is not easy to specify. If too much be present the deposit will discolour on drying ; if too little, bubbles will collect on the cathode or the deposit will oxidise in the solution. Perhaps the surest way is to try a preliminary experiment, adding the NH_4Cl till the plate begins to show discoloration on drying.

If the solution is to stand the anode may be left in it. Care should be taken to exclude the air.

On removal from the solution the cathode should be washed thoroughly in running water and drained until it may no longer be said to be wet, after which gentle heat should be cautiously applied until all moisture is removed.

The advantages possessed by the nitrate may be enumerated as follows :

1st. The weight of copper deposited does not appear to depend on the current density.

2nd. It permits the use of a high current-density.

The limit is not easily stated. When 0·25 amperes per square centimetre is reached the cathode needs watching, for it will fringe at the edge but does not become powdery.

No way was found to prevent the branching with a high current-density.

A greater amount of NH_4Cl should be present when the current density is increased.

3rd. The weight of copper is practically independent of the temperature between 10° and 35° C.

The tendency to oxidation is increased by lowering the temperature, but this may be easily counteracted by the addition of more NH_4Cl.

4th. The solution may be used a number of times.

5th. The equivalent agrees to four figures with that calculated from the best chemical determinations, viz :

Richards Eq. = $(3294{\cdot}4 \pm 0{\cdot}1) \times 10^{-7}$
First Series Eq. = $(3294{\cdot}8 \pm 0{\cdot}43) \times 10^{-7}$
Second Series Eq. = $(3293{\cdot}9 \pm 0{\cdot}39) \times 10^{-7}$

The purity of the nitrate as a condition of success is to be emphasized. One specimen tried, which contained nitrite, was absolutely worthless with the foregoing treatment.

To see what $CuSO_4$ would do under circumstances similar to those in which the nitrate was studied, a saturated solution of the sulphate was rendered neutral by the copper hydrate precipitated on addition of ammonia. NH_4Cl was added until the deposit was as bright and lustrous as that formed in an acid sulphate solution.

Three such experiments yielded

Eq. = 3295×10^{-7}
Eq. = 3293×10^{-7}
Eq. = 3294×10^{-7}

These values tend to confirm the result obtained from the nitrate ; at least they do not contradict it.

In conclusion I wish to express my thanks to Prof. A. W. Wright, under whose direction the preceding investigation was made, for his many kind and helpful suggestions.

* *Proc.* Amer. Acad., XXIII., p. 177. *Ibid.*, XXV., p. 212.

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ELECTRIC LIGHTHOUSE ILLUMINATION.

The reluctance of the Irish Light Commissioners and of the Brethren of the Trinity House to establish an electric lighthouse on the Old Head of Kinsale is, no doubt, based upon sufficient reasons, and can hardly be classed as another injustice to Ireland. Of the seven hundred and seventy lighthouses of the British Isles only six are provided with electric light. In no case where electric light has competed with other illuminants has such hot controversy raged, and such keen trade opposition been offered as in connection with lighthouses. The bitter semi-scientific discussion is now half-forgotten, but the development of electrical equipment for lighthouses has been almost at a standstill in this country; less than a dozen men have studied it. The opposition from motives of ordinary trade competition, seasoned, perhaps, for presentation to the public with a certain amount of humane and philanthropic affectation, has brought out a number of criticisms of the behaviour of electric lights. It has been nobody's business to collect statements on the other side, and the fact remains that powerful electric lights such as that at St. Catherine's Point dazzle some seamen in fine weather, compare unfavourably with oil lights to many when veiled by haze and mist, and are invisible at short distances to all in thick weather. It is not fair to suppose that the Trinity House hold up the cumbersome and wasteful arrangement at this lighthouse as a model. It was, doubtless, as good as could be got at the time, and the attempts to make a better lamp, using continuous current instead of alternate,

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were a complete failure. In France, however, there has not only been a gradual development of electric lighthouse illumination since 1864, but after experience with no less than thirteen lighthouses, some of which have since been re-constructed, they appear to have arrived at a degree of perfection which renders any comparison between St. Catherine's Point and a good oil light quite useless.

Two Papers on electric lighthouses were read at the International Maritime Congress which met in London last month. One of these, by M. André Blondel, was a communication of considerable length. We print in another column an abstract of it. A good deal of attention was paid by the author to the design and to the characteristics of alternators for lighthouse work. This we have omitted in our abstract, for we fail to see any difficulty in this part of the work. If lighthouse engineers have not succeeded in getting alternators to suit their requirements it is probably because they were unable to give a specification to which manufacturers could work. Electro-platers were in the same difficulty for many years, and like lighthouse engineers, were content with very inferior dynamos. None of the leading makers of alternators would have any difficulty in building machines to suit the work, and those who desire to do so will probably find in the original Paper sufficient information to guide them. The details of the arcs are probably of much wider interest, and these will be found in our abstract. M. Blondel goes, perhaps, rather too far in suggesting that the separation between the carbons at St. Catherine's Point is only one-third of a millimetre, but he is quite right in saying that with only 35 to 38 volts "the surfaces of maximum brightness are almost completely shaded by the carbons." "In France," he says, "it is preferred to employ a genuine arc with a pressure of 45 volts, corresponding to a separation of 4 to 5 mm. for the current of 25 amperes, and exposing the bright surfaces." While the current at St. Catherine's Point varies from 180 amperes in fine weather to 300 amperes in thick weather (this maximum current being sufficient to make 40mm. cylindrical carbons red-hot), M. Blondel does not contemplate the use of more than 100 amperes. In clear weather the light need do little more than pass the geographical limit of visibility of the lighthouse, and any great excess will surely give rise to complaints about dazzling; but it is difficult to believe, even with the superior arrangement of French lighthouses, that the "foggy weather," which allows an arc of 100 amperes to penetrate 26 miles, is anything like the fogs that hang round our side of the Channel. Another branch of this subject, which, though of limited interest to manufacturers, is very attractive from a scientific standpoint, is the construction of the optical apparatus. A most complete and, of course, admirably illustrated description of the La Hève (Havre) lighthouse was given in *Engineering* a few weeks ago. The most striking improvement, due to M. Bourdelles, is the use of only four panels, the apparatus revolving in twenty seconds, and giving a brilliant flash, lasting one-tenth of a second, at intervals of five seconds. The St. Catherine's Point light has sixteen panels, revolving once in eight minutes, and giving gushes rather than flashes of light of a duration of five seconds, and at intervals of half a minute. Prof. Tyndall has pointed out that the spaces between these sixteen beams become filled with diffused light in hazy weather, while the beams lose their brilliancy, until not only is no flashing seen, but no fluctuation of the light is visible. A fixed light periodically cut off by a screen would show sharp flashes even if the light were so diffused that the source could not be seen. M. Bourdelles' "*feu-éclair*" by an increased rotary speed and reduced number of panels is probably better, owing to the lateral condensation of the beam. We hope that the hesitation of the Trinity House with regard to the Old Kinsale Head is due to the consideration of some of these very important French developments rather than of the "monster lens" which is promised to magnify a big oil lamp to the confusion of all electric lights.

REVIEWS.

The Dynamo. By C. C. Hawkins and F. Wallis. (London: Whittaker and Co. 1893.)

The theory and design of the dynamo has been treated by almost all authors in a very ponderous fashion. They have collected notes on the observed behaviour of dynamos, and have cast them into the form of theories, and they have vied with each other in endeavouring to build up comprehensive formulæ, by combining together a number of distinct arithmetical operations. In continuous current machines, at all events, whatever ambiguities may arise with alternators, there are two principal parts called the armature and the field-magnets. It would seem to be the aim of some authors, not to reduce, but to elaborate their work, until they arrive at two formulæ, one for the armature and one for the field. Interesting as this may be to mathematicians, it does not appeal to engineers. Engineering construction is an art, and it is useless to attempt to reduce it to a pure science.

The book before us is remarkably free from mathematical complications, and, with one or two exceptions, there is no tendency to cover too much by one formula. In several respects the authors have treated the subject in an original style. There are, for example, twenty-two chapters, but the magnetisation of iron is not discussed until the twelfth, and characteristic curves are not described until the sixteenth chapter. It is addressed to students, and an elementary acquaintance with electrical science is assumed. The book is, however, sure to fall into the hands of engineers, to whom it will, indeed, be very useful; and a word or two of further explanation is required here and there for those who have picked up a general knowledge only of electricity. In explaining the connection between the ampere-turns on a solenoid and the C.G.S. strength of field, the formula $H = k \cdot A\,T/l$ is used, and k is simply stated to be "$0{\cdot}4\,\pi$, or 1·256." The appearance of $4\,\pi$ and of the divisor 10 could have been explained in five or six lines in a foot note. In several of the earlier chapters unipolar dynamos are referred to. In one place too much attention seems to be devoted to hypothetical machines of this kind, but later on we find the Mordey alternator is given as an example of the unipolar type. It may fall under the author's definition of a unipolar dynamo, but it would seem better to restrict this term to such machines as those of Siemens and Forbes, both of which are very properly omitted from the present work, as being of minor importance. The chapter on armatures may be read with interest by anyone who has already a fair acquaintance with dynamo building, but for a student or for a mechanical engineer a few more simple diagrams should be provided.

For the first time in the literature of dynamo construction the question of magnetic leakage is adequately and practically discussed, with the free use of the words reluctance and permeance, and the more generally understood and more important question of heating is dealt with at greater length and thoroughness than has yet been attempted. The portions of the book relating to these two questions require a little simplification before they are fit for use in the drawing office; to reduce them to a few definite and practical rules is no difficult matter. Descriptions of obsolete machines and laboured dissertation on the comparative merits of long and of short shunt are absent, but one or two practical matters are either omitted or are passed over too lightly. The importance of true balancing of armatures and the fallaciousness of the knife edge test should be insisted on. Instability of field is alluded to more than once, but more distinct warning should be given about

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it. The use of two wires in parallel for armature winding, when the calculated size does not agree with any stock or standard size, is suggested; but we do not find any corresponding hints for making up a shunt winding under similar circumstances, and the precautions to be observed when it is necessary to use two different gauges in series. It is probably seldom that dynamos have to be designed without the use of a table of copper wires, but in the event of such a case the authors give a very convenient rule, which is worth extracting. The resistance of 1,000ft. of copper wire of 100 per cent. conductivity, at 60°F, and having an area of 0·09 sq. in., is 0·09 ohm; or the resistance of a wire of 0·05 sq. in. is very nearly 0·05 ohm per 100 yards. Alternators are but briefly discussed, and the authors do well to leave this part of the subject until the theory has emerged from the present chaotic stage, and until alternator builders have established something better than a rule-of-thumb practice.

There is, probably, very little fresh to be said about dynamo construction, and all that an author can do is to carefully collect and arrange, and to reduce to engineering practice principles which have been already arrived at by theory or by observation. The authors have naturally availed themselves of the writings of Hopkinson, Kapp, Swinburne, and Esson, but in several cases a little more condensation might have been effected. In the absence of any good text books on electricity and magnetism, the first six chapters are perhaps necessary. They form an excellent introduction to the main purpose of the work. We should like to see a more marked distinction between this theoretical part, which should be learned at college, and the account of the construction and designs of dynamos, which cannot be properly learned anywhere but in the workshop and drawing office. We welcome this book as a thoroughly trustworthy and useful work.

Electrical Tables and Memoranda. By S. P. Thompson and Eustace Thomas. (London: E. and F. N. Spon.)

This little pocket-book, measuring $2\frac{3}{4}$in. by 2in. by $\frac{1}{4}$in., suggests by its title the proper aim of a pocket-book—tables and memoranda. Tables in the first place, for it is impossible to remember a table, and memoranda in the second place; but these should be confined to matters which are difficult to remember. Some tables consist of the mere working out of a simple formula, entailing a single arithmetical operation. To print these in a large pocket-book, instead of the formula, is a matter of labour-saving. Such, for example, are the tables of circumferences of circles and conversion of thermometer scales. The present pocket-book contains about twenty tables, but is cumbered by none of this simple class. In a larger book, labour-saving tables are useful, and might sometimes be accompanied with advantage by diagrams giving the same results in the form of curves. The **B H** curves of soft annealed iron, iron hardened by stretching, steel, and steel glass hardened, are given on a very small scale, the diagram being only about 1in. square and the scales given without square rulings. A numerical table of **B**, μ, and **H** of annealed wrought-iron and of grey cast-iron is given, and occupies three-quarters of a page. One of the advantages of giving such information in the form of curves is that a considerable number of curves may be drawn on one diagram and occupy no more space than a single one. The limit is only reached when the curves become so numerous, or cross each other at so small angles, that there is a difficulty in following them.

It is rather difficult to criticise the memoranda in this pocket-book. The authors offer certain morsels of information which are no doubt memoranda in the sense that they are worthy to be remembered; but if this were the sole criterion we could not complain if a list of the days of the week were included. A good deal of condensed text-book matter, laboratory notes, and workshop instruction is given, all excellent of their kind, but we think unsuitable for a pocket-book in which space is, or should be, so valuable. It is not difficult to say if a text-book be complete or not complete; it should contain all that is necessary to be known up to a certain point, depending on its size. But a pocket-book of this kind should not attempt to give new or original information, but should consist of well condensed matter which is difficult to remember. A short trigonometrical table appears to us to be indispensable, even if limited to sines, cosines, tangents and cotangents of angles. No such table is given, but a short table of logarithms is provided. Logarithms must be classed with labour-saving tables. No one can judge what is easy or what is difficult for another to remember, and unlike text-books, the more pocket-books there are the better, so that each can choose for himself the one that is best suited to supplement the particular shortcomings of his memory.

Handbook on the Steam Engine. By Herman Haeder. English Edition. Translated by H. H. P. Powles. (London: Crosby Lockwood and Son.)

The vagueness of the term "handbook" is again illustrated by the title and contents of this work. We have here what, except for its size and shape, would ordinarily be termed a pocket-book, inasmuch as it is a collection of tables and dimensioned drawings of steam-engine details, for use in an engineer's drawing office.

The data are entirely empirical, being based, not upon considerations of stress and strength in the details to be designed, but upon what, for want of a better term, we may call the "method of imitation." This method consists in designing or drawing in strict proportion to some established pattern, details of the proportions of which are tabulated in the book. The process is not uncommon among draughtsmen, and is perfectly safe as long as the draughtsman understands the principles of his work and the reliability of the materials he is proposing to use. The danger in such a work lies in its tendency to create machine-made draughtsmen, who, as long as the work does not carry them off the lines of established practice, are able to compete with superior and fully qualified men, but who, directly they are faced by something entirely new, either fail to produce a design or, worse still, produce one which conceals faults which may end in disaster.

It is, of course, of great value to possess in a compact volume the tabulated practice of so many English and Continental firms of engineers as is to be found in this work, and we have no hesitation in saying that as such the book ought to find a ready place in drawing offices. It abounds in diagrams of engine details, about which, if we can have any complaint, it is that they are in many cases too small. The large plate showing very clearly the internal arrangements of a Willans central valve engine would have been more serviceable had it represented the later pattern of that engine, into which many important improvements have been introduced.

Lecons sur L'Électricité. By Eric Gérard. Third Edition. Two vols. (Paris: Gauthier-Villars. Liége: Léon de Thièr. 1893.)

We have already reviewed at some length (see *The Electrician*, Vol. XXVII., p. 327) the former edition of this excellent work; and we, on that occasion, congratulated the French student upon his having available so comprehensive, so scientific, and so clearly written a work as the one before us. Considerable additions have been made in the third edition, and the various sections give evidence of having been brought well up to date. Among these new features we notice sections upon polyphase motors, electrometry, new dynamos, traction, and lighting. Two new and important chapters have been added, the one dealing with telegraphy, the other with telephones and the combination of telephony with telegraphy on the same circuit. The author also discusses some of the latest developments in the theory and use of alternating currents. While this work is confessedly to a large extent a compilation, it is none the less valuable on that account; for the utmost care has evidently been exercised in the choice of suitable material, and copious references are given to the sources from which information has primarily been obtained.

Alternating Currents of Electricity. By Gisbert Kapp. (New York: The W. J. Johnston Company.)

This small and elementary text-book has been reprinted from the "Professional Papers of the Corps of Royal Engineers," with an introduction by Mr. Wm. Stanley, jun. It is quite evident, though there is no direct intimation of the fact, that the book contains the substance of a series of lectures. It is a great pity when traces of a lecturer's style, in using such phrases as "I have here a coil," or "You will observe the diagram on the wall," or "I use the bottom of an ordinary

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biscuit tin," &c., are left in all their nakedness for the eye of posterity. A little careful revision would turn what looks like a *verbatim* lecture report into palatable and instructive reading, for, however admissible such phrases may be in the record of a society's proceedings, they do not help the reader of a text-book. The first four chapters of the work are devoted to an explanation of alternating currents and their measurement; the next three to the principles and design of alternators and transformers. Chapters VIII. and IX. describe some alternating-current stations, and Chapter X. deals with methods of parallel running. The remaining chapters relate to alternate-current motors and the use of multiphase currents. There is a general belief that text-books of alternating currents are almost synonymous with higher mathematics; and the difficulty hitherto has been to produce a readable and useful book for non-mathematicians. Mr. Kapp has attempted to cut the Gordian knot by transferring the difficult mathematics, of which there is not a great deal, to a series of short appendices.

The Management of Accumulators. By Sir D. Salomons. (London: Whittaker and Co.)

This little work forms the first volume of the seventh edition of a work which has previously been known under the title of "Electric Light Installations and the Management of Accumulators." We understand that the work has been revised and enlarged, making it necessary to publish it in more than one volume. The first volume embodies the results of the author's experience in the management of secondary batteries for private electric lighting work.

THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 446.)

The filaments must, of course, be measured before mounting and flashing, and it is well to measure them again after flashing, to see that the increase in thickness is of the proper amount. The measurement may be done in several ways by means of micrometer gauges, or by throwing a magnified image of the filament upon a screen by means of a lamp and lens, or by the ordinary microscope method, which, however, cannot be considered a factory method. Measuring with a micrometer can only be done with accuracy after a considerable amount of practice. The best form of micrometer to use is that represented in Fig. 21, which can be read to the fifth part of a mil. It should be mounted on a support fixed to the table, so as to be about three inches above the table, and so that the screw head can be turned easily with the thumb and fore-finger of the right hand, with the fore-arm resting comfortably on the table. The filament will be held very lightly between the thumb and fore-finger, or between the first and second fingers of the left hand. Great delicacy of touch is required, as the filament may be squeezed to a considerable extent, and the measurement will be wrong. Some micrometers have a ratchet-head, so that they may be screwed up until the object to be measured is held just so tightly that the ratchet head slides round without closing the gauge any further. This arrangement is, however, not sufficiently delicate for filaments. They may be squeezed much too tightly before the ratchet comes into play. Of course a ratchet-head might easily be made to work with a very slight pressure, but the difficulty is to get one which will turn the micrometer screw without anything in the jaws, a considerable force being required to do this, and yet which will slip on the slightest extra resistance. A micrometer without the ratchet-head may be used, and it can be screwed up until it is felt that the filament is being touched, but it is difficult always to squeeze to the same extent. A much more accurate plan is to slowly move the filament backwards and forwards in the direction of its length between the jaws of the micrometer which are steadily and slowly being screwed up with the other hand. Immediately the filament is gripped, ever so lightly, it will be felt by the fingers holding it, before, indeed, the fingers of the other hand turning the micrometer feel the resistance at all. Filaments can in this way be measured very accurately. When the filaments are not properly circular there is sometimes a difficulty in getting the greatest measurement, as the micrometer will tend to turn the filament round so that it measures always its least diameter.

The method of projecting a magnified image of the filament or a part of it upon a screen is very accurate if properly carried out, but it requires two person to work it, one to put the filaments in position, and the other to read the result on the screen, if the measurements are to be made as quickly as with the screw micrometer. The larger the image the more accurately can it be measured on the screen. There are, however, two difficulties in making a large image. Either a very short focus lens must be used, in which case a slight error in the position of the filament will make a considerable error in the size of the image, or, if a long focus lens is used, the distance from the lens to the screen will be inconveniently great. In any case, an achromatic lens should be used, or the image of the filament will be blurred, on one side in red and the other in blue.

If the filament is magnified one hundred diameters, the screen may be divided in tenths of an inch, in which case each division will represent one mil in the filament. The screen may be made to slide either in a vertical or horizontal direction, according as to which way the filament is held, so that the zero line of the scale may be brought to the edge of the image of the filament. Another method is to use a scale

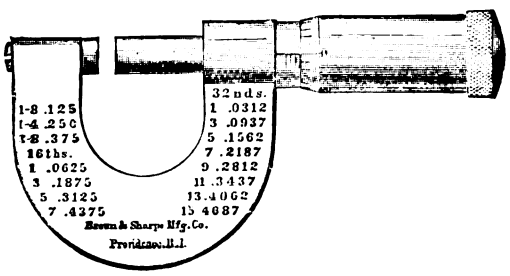

Fig. 21.—Micrometer Gauge, for Measuring Diameter of Filaments.

drawn on glass, the image of which is thrown together with that of the filament on to the screen. There is a slight error here, as the scale must, of course, be either in front or behind the filament, and will, consequently, be either a little too large or too small. This error will be unimportant if the lens be an inch or more in focal length, though the image of the scale may not be quite sharp. If the lens has a focal distance of one inch, the distance of the screen from the centre of the lens will be 8ft. 5in., while the filament will be 1·01 inches from the centre of the lens. This is rather inconveniently close for the handling of the filaments, but a greater focal length of lens requires a correspondingly greater distance to the screen. A lens of three inches focal length gives more room, but the distance of the screen will then be over 25ft. A powerful illumination is required in order that the image on the screen may be easily distinguished. An incandescent lamp similar to those made for lantern purposes answers very well, the light being concentrated on the filament by a condensing lens in the usual way. This method is very useful in determining the diameter of a filament after it has been made into a lamp, the filament itself being rendered incandescent. The filament is placed in the right position by getting it in line between two fixed wires or narrrow slits in metal plates on either side.

A lamp bulb is one of the very simplest things which a glass worker can have to make. Everything which is made direct from the glass pot is, in fact, made first of all into a bulb in some form or other. Pressed glass is, perhaps, the only exception, as it is merely a lump of glass dropped into a mould and pressed. This, however, does not mean that there is no skill required in the making of a lamp bulb. The method of working is as follows: The glass worker has an iron tube some five or six feet long; he dips the end of it,

* Abstract from a book to be published shortly by *The Electrician* Printing and Publishing Company (Limited). All rights of republication reserved.

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after first heating it, into the molten glass and "gathers" some glass on the end. There is considerable skill required in gathering the right amount. He then withdraws the tube, and holding it out in a somewhat inclined position, the end with the glass upon it being higher than the near end, he blows through the tube, at the same time turning it round and round, and in this way forms the glass into a hollow bulb. If he wants the bulb to assume a long or pear shape, he whirls the tube round and round as one may twirl a walking cane. It requires much skill to produce bulbs of the same size and shape in this manner, but good glass workers are able to make wonderfully uniform bulbs in this way.

There is, however, another method, not requiring so much skill, by which the bulbs are all made exactly of the same size. They are blown into a mould, such as shown in Fig. 22. The mould is made of iron, and is lined with plumbago. The glass worker, having gathered some glass on his iron tube, stands on a low platform or stool, and places the end of the tube with the glass on it in the opening of the mould, which a boy holds in position on the ground. He blows down the tube, and twirls it round between his hands at the same time. The glass is blown out so that it fills up the space in the mould. The boy then opens the mould, and releases the bulb, which is then cut off from the tube. Wooden moulds may be used if only a few bulbs of an odd size are wanted. Apple wood answers the purpose. The bulb is blown in just the same way. The surface of the mould quickly becomes charred or carbonised, and thereby protects the wood below the surface. A number of bulbs may be made in it before it perceptibly increases in size. Pump bulbs and the like may

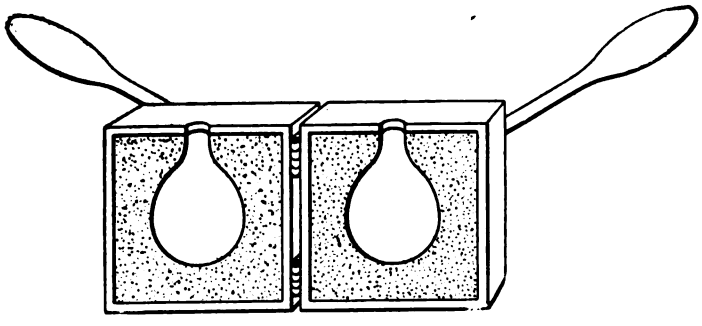

Fig. 22.

very well be blown in wooden moulds, as also may the globes or shades for the flashing apparatus. For these latter the mould need not be so complete. It is sufficient if the mould be simply a cylinder open at both ends.

The only other article required in a lamp factory, made directly from pot glass, is glass tubing. Quantities of this of various sizes are required. Small sizes are used for making the tubes which are joined to the bulbs, and through which the air is exhausted; and larger sizes for the mercury pumps and other apparatus. The method of making the tubing is very simple. The tube begins, as most things do, with a bulb at the end of the glass worker's iron tube. A lump of glass is first gathered from the pot upon the end of an iron rod, which is then given to a boy to hold, glass uppermost. The glass worker then gathers glass on his iron tube, in quantity according to the size of the tube he is going to make, and forms it into a hollow bulb. If the tube is to be of large diameter it will be a large bulb, and will require a good deal of rolling on an iron plate, and re-heating at the mouth of the crucible before it is of the proper shape. It must be perfectly round inside and out, or the tube will contain along its whole length any defect in the shape. Having got the bulb into the required size and form, the glass worker turns it over so that the end of it is brought into contact with the glass at the end of the rod which the boy is holding in readiness to receive it, and to which it will adhere. The iron rod and the tube are then both held horizontally, and are turned round and round, while the boy at the same time walks backwards, thus elongating the bulb, and drawing it out into a long tube. The tubing is made in this way many feet long. For a considerable length in the centre of the piece it is, probably, of nearly uniform size, though towards each end it will be larger. When it is pulled out sufficiently, and becomes rigid, it is laid on the floor across pieces of wood placed ready to receive it, and is then cut up into lengths, which are afterwards sorted into the different sizes. A good glass worker can so manipulate the glass as to produce within a very little the exact size of tube which is required.

The art of glass-blowing consists in softening glass in a blow-pipe flame, and then working it into the desired shape or form. The incandescent lamp industry has had to produce its own glass blowers. In the early days of incandescent lamp making there were few skilled glass blowers, and many of them were only skilled in making perhaps one particular article. Thus, a man who was used to making spiral-bulbed thermometers would in all probability be a very poor hand at "sealing in" a lamp filament. He would demand an extortionate rate of pay, and would work excessively slowly, and he would not work at all if anyone was standing by, as he did not wish to give away the secrets of his trade. It was on account of this kind of thing that Messrs. Wright and Mackie brought out their glass-blowing machine, a machine specially designed for making lamp-bulbs out of tube, and for sealing in the filaments, all without the aid of the professional glass blower. Bulbs made straight from the glass-pot—"pot bulbs," as they are sometimes called—were not made at the time. The bulbs were all made from the tube. The glass-blowing machines, however, never came into general use, partly on account of the introduction of pot bulbs and partly because it was found that a new race of glass blowers, without the prejudices of the old hands, was springing into existence. It was

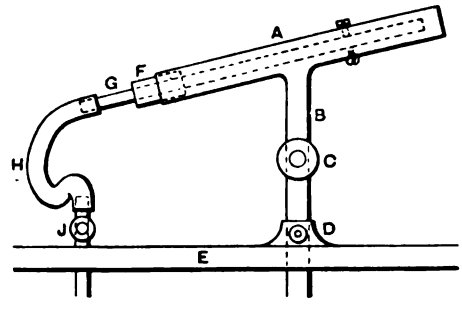

Fig. 23.

found that lads who were handy with their fingers could soon learn not only to seal in, but even to make good bulbs, and many of them even to do the more difficult work of making pumps. A lad or a girl at a fraction of the wage of the professed glass blower would do more work, and yet be well paid.

Complicated glass work for chemical and other apparatus, which many glass blowers were accustomed to make, is of necessity done in a very slow and deliberate manner. A moment of impatience, too quick heating or insufficient annealing of a part, might spoil a whole day's work. This is no doubt the reason that glass blowers appear to work so very slowly. Such a slow rate is, however, quite unnecessary in lamp making. The really skilled glass blowers are not found in lamp factories, for the reason that they are not required, and that it pays them much better to make chemical and other apparatus, which always commands a good price.

The blow-pipe most commonly used in glass-blowing is that called the "cannon." Various forms of this blow-pipe of a more or less elaborate construction, are made, but the simplest and cheapest form, shown in Fig. 23, is the most satisfactory. It consists of a piece of brass tube, A, open at both ends, joined to another tube, B, at about the angle shown in the figure. C is a screw stop-cock. D is a socket through which the tube B slides, so that the whole can be raised or lowered and fixed by the thumb-screw in D at any convenient height above the table E. Below the table the tube B is joined by a flexible tube to the gas supply. F is a cork with a hole bored through its centre to accommodate a piece of glass tube, G. About two-thirds up the tube, A, three screws pass through it and act as guides to the inner glass tube, G, and keep it in

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the centre. The end of the glass tube G is joined by a piece of flexible tube, H, to the air-blast through the stop-cock J.

Almost any kind and size of flame may be obtained with this blow-pipe, depending on the regulation of the gas and air blast by the cocks C and J. It is necessary, however, to use a larger bore glass tube, G, for the large flame than for the smaller ones, while for the small pointed silent flame the nozzle of G must be considerably contracted. It is a matter of importance that this glass tube be quite straight and regular and smooth inside, and that both ends of it, especially that from which the air issues, be cut off perfectly straight across and at right angles to the tube. This tube can be shoved in and out through the cork and adjusted to its proper position. It should not reach to the end of A by a quarter of an inch or so.

(To be continued.)

OCEAN TELEPHONY.*

BY SILVANUS P. THOMPSON, D.SC., F.R.S.

(Concluded from page 440.)

CASE 2.—*Use of Mutual-Induction Devices Distributively.*

In this case the cable is considered in sections, each of which is in inductive relation with those on each side of it; and again there are many possible varieties included. One example is as follows:—Let the two conductors along the cable be each divided into a number of equal lengths, and let the parts be joined together by mutual-induction coils, that is to say, by induction coils with two windings each. Though the

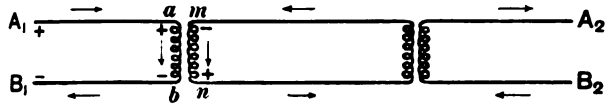

FIG. 7.

exigencies of cable-laying will necessitate some very different shape of coil or device as an organ of mutual induction, we may assume these induction coils to be of the familiar form of an iron core surrounded by the two windings. The cable so made up of sections will be indicated by Fig. 7.

In this figure it is indicated that the coils are so connected that in the A line when the current is increasing and flowing

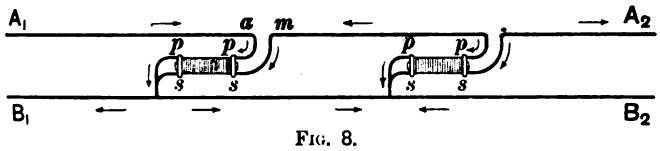

FIG. 8.

toward *a*, the inductive action will be causing a current in the next section, which will be at the same instant increasing, but flowing, so far as the A line is concerned, in the opposite sense, so that while the potential of the point *a* is rising that of the point *m* is falling. The consequence will be that the currents required to sweep out any accumulated charges due to capacity will not have to travel (as in ordinary cables) all the way from the ends of the cable, but need only travel short distances, never more than the length of half a section. Hence, if a cable

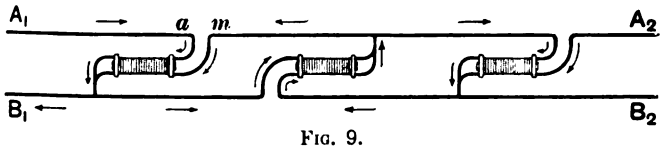

FIG. 9.

2,000 miles long is cut up into 25 sections of 80 miles each, there should be no more retardation than on an ordinary cable 40 miles in length. It is not needful that both the lines should actually be divided: a virtual division into sections is effected in Fig. 8, where the B line is actually continuous. In this figure *p p* is the primary, and *s s* the secondary (or *vice versâ*) of the mutual induction coil. Or the arrangement may be alternated, as in Fig. 9.

Or again, if three conductors are employed—of which one may be the sheathing—the sectioning and use of mutual-induction may be accomplished as shown in Fig. 10.

Here, again, as remarked above, the kind of induction coil which naturally suggests itself as suitable for the purpose in question is something of elongated shape, such as a

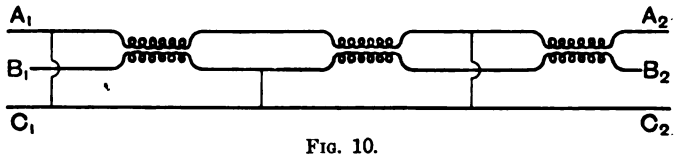

FIG. 10.

very elongated loop "shell" transformer, or the "cable" transformer which was suggested for electric lighting purposes by Messrs. Siemens and Halske some years ago. Or, as the author suggested in 1891, by using a mutual induction between the wires of the cables themselves by merely enwrapping them, as they lie side by side, with iron. So that the cable once more becomes an arrangement of three parallel

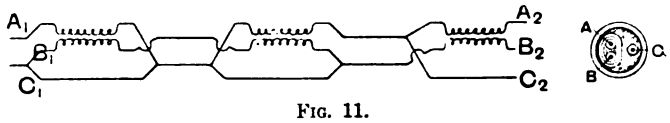

FIG. 11.

wires, of which two are specially brought into mutual inductive relations to one another, and are joined up at intervals, as indicated in Fig. 11.

Lastly, it is, as is well known, possible to have mutual induction between two wires that do not form part of closed circuits, as in the phonopore of Mr. Langdon Davies.

III.—EVIDENCE AS TO PRACTICABILITY OF USING INDUCTION DEVICES DISTRIBUTIVELY TO COMPENSATE RETARDATION.

With the facts already known that the Varley shunt does indeed operate at the ends of a cable to compensate in some measure the effects of capacity near those ends, and that on long landlines the speed of signalling can be increased by inserting a translator in the middle, or even by a mere leak at some intermediate point, it is remarkable that no one should have suggested hitherto the very simple solutions now proposed. Perhaps the reason is to be found in the intense horror with which all good telegraph engineers regard the idea of having a fault on their line. Deliberately to insert, as the author proposes, a series of faults, as shunts across the cable from the going wire to the return wire, will, to many of them, appear sheer madness. The shunts are not mere faults, however. They are bridges possessing considerable resistance, and, what is more to the point, considerable self-induction. They are not leakages, through the insulation to the sheath, of an unknown amount, and one liable to increase by corrosion; they are as fixed and determinate as the resistance of the cable itself. Telegraph engineers have long known in general the virtues of an inductive shunt. In the third volume of the *Journal of the Society of Telegraph Engineers*, 1874, Mr. G. K. Winter describes the use of inductive resistances in cable signalling, such shunts being used at the ends of the cables, as Varley had previously used them. The idea of using such Varley shunts distributively along the cable appears to have been vaguely in the mind of no less eminent a telegraph engineer than the late Mr. Willoughby Smith, who, in 1879, read a Paper on the working of long submarine cables to the Society of Telegraph Engineers. In this Paper, after recounting some experiments made with Varley shunts—or what he seemed to think such—he adds: "I was under the impression that by a judicious distribution of electromagnets on subterranean lines greater speed might be obtained." But he seems to have been deterred from following out the idea by finding that the solid core electromagnets which he was using failed to operate favourably; and he even declared that such minute currents as were used in cable signalling were "totally inadequate to produce perceptible electromagnetic induction

* Paper read before the International Electrical Congress at Chicago, August 22nd.

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effects." We now know from telephonic experience that this is not so; even the minutest telephonic currents being perceived, simply because they can produce sensible electromagnetic effects.

Other electricians have proposed to use shunts containing electromagnets from line to earth for various purposes. Amongst them Mr. Lockwood and Mr. Edison. The latter in his patent, No. 135,531, applies such shunts to overcome the static charge on lines. The author in 1884 proposed to apply such shunts to enable him to introduce a battery current into a telephone line without diverting the working telephonic currents. Again, it has been found in telephone work that a telephone receiver placed across from line to earth, as a shunt or bridge, does not prevent another receiver further down the line from receiving its proper current. This bridge method of arranging telephonic instruments has for years been used in the British Postal Telegraph service. In 1890 a most suggestive communication was made at the Detroit Convention of the American Association by Mr. J. J. Carty on "Bridging Bells," in which he described arrangements of way-lines in which the electromagnets of the bells instead of being inserted in the lines (where their impedance would prevent telephonic talk), were set as bridges or shunts from line to earth. He found * a way-line with eight such shunts upon it at eight intermediate stations to transmit speech *better* than it did with only two stations. In this case the coils used had resistances of 1,000 ohms, as measured on the Wheatstone bridge; but, with a magneto-generator giving an alternate current the impedance was about 10,000 ohms. Again, when in 1891 the London-Paris telephone line was constructed by Mr. Preece, with a special cable about 20 miles in length from Dover to Calais in the middle of it, the circuit being metallically closed, it was found that the talking from London to Paris was in no way interfered with when telephonic receivers were bridged across the circuit at the two ends of the cable. In fact such bridging rather improved the working of the line. It is therefore reasonable to suppose that by systematising the arrangements, of which more or less imperfect glimpses are afforded in these instances, and by providing a cable with inductive shunts at proper intervals all along so as to balance the capacity from point to point, in a distributive manner, the longest cable can be made to transmit speech, and if speech, the less frequent impulses of automatic telegraphs.

Many experiments have been made in the author's laboratory with arrangements of apparatus set up to imitate by condensers and resistances the retarding properties of actual cables. An example will suffice. A section of artificial cable was made up of a resistance of 7,000 ohms, and a capacity across between line and earth of 10 microfarads. Through this cable not a sound could be transmitted telephonically to a double-pole Bell receiver at the distant end, either with a Blake transmitter (with induction coil) or with a Hunnings transmitter without induction coil. When, however, a single compensating self-induction coil, having a resistance of only 312 ohms, and a time constant of about 0·005 second, was bridged across at an intermediate point, telephonic transmission became at once possible, save for very shrill sounds.

One curious result came out in one of the series of experiments, namely, that those telephonic transmitters which have induction coils in them (the ordinary mutual-induction coils with thick and thin winding), are almost useless for the purpose of cable transmission. Apparently the fine-wire winding has too great a self-induction in series in the circuit to be suitable for this purpose. At any rate, better results were obtained from transmitters of other types. Quite recently the author has got better results from a transmitter in which the ordinary two-wire mutual induction coil was replaced by a single self-induction coil on a plan suggested by him in 1884. It is obvious that any plan which contemplates the counterbalancing of retardation by shunting (through self-induction coils) a notable fraction of the current may necessitate a new type of transmitter capable of sending telephonic currents of much greater amperage than those ordinarily used in overland telephony.

* See *Electrical World*, Vol. XVI., p. 208, 1890.

So far, the evidence for the effective operation of self-induction has been considered. But there exists also much evidence to show that mutual induction by devices properly distributed along a twin-wire cable will also be effective in neutralising the retardation due to distributed capacity. It is an old and well-established rule that the retardation in a cable is proportional to the square of its length. If one could cut a 2,000 mile cable into two cables of 1,000 miles each, and simply translate or relay the current from one into the other, the retardation of the whole ought to be reduced very materially, perhaps not to one quarter, but at least to one-half. Only here, again, it is evident that some of the electric energy supplied at one end must be used up in the act of working the translator or relay, however it is constructed, even if it be only a simple mutual induction coil. Therefore, if a cable is cut up into numerous sections, each connected by mutual induction with the next, a considerable fraction of the energy put in at one end may never reach the other, being spent on the road in overcoming the retardations that would otherwise arise. For land lines it has often been proposed to cut up the line into parts, as for example, by Edison in his patent No. 150,848, in which for the attaining of greater speed he shows a line divided at three intermediate points where the circuit is grounded through mutual induction coils. The objection to ordinary induction coils for this purpose is that they are never well enough made from the inductive point of view. If they are not so constructed that *all* the magnetic flux due to one of the sets of coils interlinks itself with the other coil, then each coil will possess an unbalanced self-induction, and will offer an impedance. Mutual induction, as is well known, tends always to wipe out the self-induction of both the circuits thus brought together; but with the most perfect conditions of magnetic circuit, the utmost that the mutual induction can effect is to neutralise the self-induction

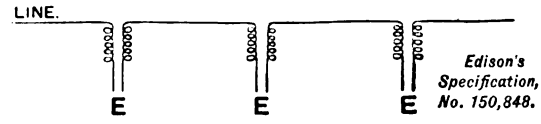

Fig. 12.

only of those coils which are acting as mutual inductors. It cannot neutralise the self-induction in parts of the circuit beyond. Hence, for the particular purpose in question—namely, that of enabling the circuit to transmit telephonic signals—the induction devices must not be simple ordinary coils inserted haphazard at intervals; they must be specially designed and inserted with perfect regularity. And the cable itself must be freed as far as possible from self-induction. *Never, for such a purpose, must a cable be constructed, as Atlantic cables have hitherto been, of a single conductor* (of stranded copper) *surrounded by an iron sheathing* that comes in between the outgoing and the returning parts of the circuit, thus adding an enormous impedance. Happily, in all twin cables where outgoing and returning conductors lie side by side within the sheath, the iron of the sheath, enclosing both, increases the mutual induction between them. As the author pointed out in 1890, in the discussion on the London-Paris telephone line, the mutual induction of the twin cable is a positive gain, enabling transmission to take place far beyond the limits previously assigned from considerations as to capacity and resistance alone. In such constructions as Fig. 6 the iron used to increase the self-induction of the wires that act as compensators will of itself increase the mutual induction between the twin conductors if they are properly disposed. The experience gained with alternate-current working is absolutely conclusive as to the efficient action that may be expected in special constructions for future ocean telephony.

IV.—Conclusion.

Ocean telephony is possible. The means for attaining it are within our grasp. Compensated cables of the new type are entirely practicable. It may be needful to begin with some shorter line than an Atlantic cable, in order to gain experience. But an Atlantic cable constructed on the new

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plan will not cost much more, when laid, than one of the old type; and whether or not it is successful in conveying telephonic speech, it will certainly transmit telegraphic messages at a greatly accelerated speed of signalling. If one Atlantic cable can be constructed to do the work now requiring eight cables, that cable will be constructed. Acceleration of the ocean telegraphic service is in itself a desirable step in advance; but the advance will not be complete until telephonic speech is transmitted also from shore to shore.

THE AZORES CABLES.

The opening of cable communication between Lisbon and the Azores Islands was inaugurated by the King of Portugal on the 27th inst. at the Eastern Telegraph Company's station at Carcavellos, near the Portuguese Capital, in the presence of the leading officials of the country and some 400 distinguished guests.

The negotiations for laying this cable have been carried on for some 20 years, and finally, after a keen competition with the French Société des Téléphones, who last year secured the concession, but allowed it to lapse, it was granted to the Telegraph Construction and Maintenance Company, who laid the cables within about two months from the signing of the contract, a promptitude which forms a record.

The sections, with their approximate lengths, are as follows:—

Lisbon to Ponta Delgada, St. Michael	940 knots
Ponta Delgada to Horta, Fayal	200 „
Horta to Island of Pico	5 „
Pico to Island of San Jorge	12 „
San Jorge to Island of Gracioso	25 „
San Jorge to Island of Terceira	30 „
Total	1,212 knots.

The first two cables are to be worked by the Europe and Azores Telegraph Company (Limited), of which Sir John Pender is Chairman, which is to take over the cables from the Telegraph Construction and Maintenance Company; and the inter-island cables are to be worked by the Portuguese Government.

The Azores, and especially Fayal, have long been recognised as a health resort, and now that the islands are in telegraphic communication with the rest of the world, no doubt an increased number of people will visit them. The climate is delightful, the range of temperature small, the scenery exceedingly fine, and living very cheap. No doubt, also, now that it is possible to telegraph, additional shipping will call, especially as coal can be obtained either at St. Michael or Fayal. A Portuguese lines of steamships runs from Lisbon to the different islands. Telegraphic communication will also have some value for meteorological purposes, as many of the storms which pass over America in an easterly direction are dispersed, and do not reach this country; and, as there is no available island in the North Atlantic which could be placed in cable communication with Great Britain, telegrams from the Azores will in some cases enable more accurate forecasts of the weather to be made. Fruit of almost all kinds grows freely at the Azores, and a considerable trade is done with Europe. At one time St. Michael oranges were famous, but for some reason the quantity of this fruit produced is very much less than it used to be. The Azoreans are "Home Rulers," and wish to have the right to manage their local affairs. It is to be hoped and expected that the telegraph will increase the prosperity of the islands, and serve to develop Portuguese commerce and enterprise.

The march of the telegraph is ever onward—*sub mari per terras*. Some years ago it was said that there would be little work in the future for cable manufacturers, but each extension in time requires its duplicate and triplicate or alternative lines, and in many cases necessitates further extension. It is only 27 years since ocean telegraphy was proved practicable, and now there is no important place or port of the world which is not connected with the great network of international telegraphy which, octopus-like, stretches its tentacles all over the civilised globe. There are about 150,000 miles of submarine cable, and over 2,000,000 miles of land line. To-day the Azores are connected, and before the end of the year the Seychelles and the Mauritius will be placed in telegraphic communication with all parts of the world.

HIGH-SPEED RAILWAYS.

It is popularly supposed, and there are, we fear, men calling themselves engineers who share the idea, that the problem of rapid transit simply consists in getting more power into a locomotive so as to enable it to overcome the various resistances at a higher speed. This, while it undoubtedly is one of the points to be developed, is not the only nor the most important detail in the problem. The conditions which have led to a speed of sixty or seventy miles an hour becoming the limiting speed of railway transit are by no means confined to the structural difficulties involved in designing a steam locomotive to draw a train at a higher speed. On the contrary, there is no good reason for supposing that a high-speed locomotive would be impossible of construction. The practical difficulties are to be found mostly in the construction of the permanent way; the remaining difficulties being principally of a financial nature, and relating to the increased cost per train-mile as the speed is increased.

The existing steam railway lines are invariably designed to suit a definite limiting speed of transit; and the advent of a more rapid locomotive would not accelerate traffic over these lines Three principal points are kept in view in this relation, namely, the design of the rail section and gauge, the setting off of curves and of the transition gradients. The greatest difficulty would be found at the curves, and, possibly, at the transition gradients. The curve consists of two parts, the curve proper and the transition curve. The former is set off at a radius which is a fraction of the speed, such that other things being equal the radius will vary directly with the square of the maximum speed of a given coach going round the curve. It is always possible to modify matters so that the radius may not be required to increase with the speed at this enormous rate, as, for example, by adopting a more severe rise of the outer rail so as to throw the centre of momentum of the car nearer the centre of curvature. But this practice has attained its necessary limit when the amount of radial tilting of the line has become so large that it would be positively dangerous for a coach to be run over the curve at any very much lower speed. In any case, the existing curves would have to be greatly enlarged if required to suit a higher speed. The transition curve is an evolute, which is designed to avoid the sudden and highly-dangerous shock which a coach would receive if it passed immediately from a straight run to a curve of fixed radius; and its geometrical form is such that there is a steady and gradual diminution of radius from infinity to the value of the radius proper as the coach passes on to the curve. Inasmuch as the kinetic energy of a moving body is proportional to the square of its speed, it will be seen that the amplitude of the transition curve, which will produce the same time rate of change in the momentum of the coach, will increase enormously as the maximum speed is increased. Turning next to the transition gradients, we meet with similar difficulties. These gradients are the gradual development of the track from one gradient to the next in order to prevent either the shock or the tendency to "jump the rail," which would take place if a coach passed instantaneously from one gradient to another very different one. When the speed is high, there would be the altogether incurable tendency of the coach to become derailed whenever the passage is in the opposite direction; incurable, that is to say, except by a complete resetting of the gradients. These points each indicate that in order to have any very much more rapid transit than we now have, it will be necessary to set out an entirely different system of permanent ways, and to re-design every detail of the track.

Nor must the permanent way alone be changed, for it will be necessary to alter the distribution of motion within the locomotive itself in such a way as to render high speed physically possible. From some cause or other it has been found impossible to attain a higher speed than 80 miles an hour by means of an ordinary steam locomotive. The reasons for the limit have been much discussed, but its existence is scarcely disputed by competent engineers. Some have considered the cause to lie in the rapid increase of frictional resistances with increasing speed; some have attributed it to the high-back pressure and the wire-drawing consequent upon larger piston speeds; some again have endeavoured to prove that the coefficient of friction.

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between the driving wheels and the rails diminishes as the speed rises, so that a limiting speed must be attained. But the most satisfactory and complete explanation is that which was put forward in 1891 by Mr. E. L. Hill, in a Paper which he read before the students of the Institution of Civil Engineers. While admitting the importance, in a minor degree, of the reasons which we have just enumerated, Mr. Hill conclusively showed that there must of necessity be, in every reciprocating-engine locomotive, forces which it is impossible to balance, and the direct effect of which must be to periodically reduce the load on the driving wheels. So great, indeed, is the fluctuation of dead weight on either of the two driving wheels of an express locomotive that even at normal speeds the value of the adhesion falls very nearly to the simultaneous value of the tractive effort. It would require but a small addition to this normal speed to bring the value of the former quantity below that of the latter, and then, of course, the wheels would begin to slip, and further acceleration would be impossible. More than this, the state of slipping of the wheels on the rails would change the friction from statical to sliding, resulting in a drop in the numerical value of the coefficient of friction to half or less than half of its former value, according to the speed. It will, therefore, be seen that a high-speed locomotive—or one which is to draw a train at more than about 80 miles an hour—will require to be driven by machinery of a rotary type.

Turning lastly to the difficulties of a financial nature which would be encountered in working a high-speed railway system, we are brought face to face with the fact that almost on every hand the increase of speed must raise the cost per train mile, as compared with the cost of the same system running at a lower speed. The single exception to the increased cost is the turnover of the capital invested in rolling stock, for at a higher speed a coach would carry more passengers any given distance in any given time. The losses during steady running would be chiefly due to windage and rail friction, and it is probable that the power required to overcome each of these would increase as the cube of the speed; and, inasmuch as the larger part of the time of running would be spent in fairly steady running, it follows that the annual cost of power will be increased almost in this ratio. When getting up speed energy must be stored in the moving coaches, and this is wholly wasted in the brakes. Since the amount of this energy is proportional to the square of the speed, and since the number of stoppages per annum will vary directly with the average speed of running, it follows that in this particular also the energy consumption varies as the cube of the rapidity of transit. Considering a concrete case, these facts imply that to run a given railway system at 100 miles an hour would cost nearly five times as much as to run the same system at 60 miles an hour. It is doubtful if many folk would be willing to pay the two-third power of fivepence per third-class mile, instead of a penny, in order to get over it more quickly; indeed, Max O'Rell tells of a Scotchman who rejoiced at having to travel in a slow train because of getting "more for his money."

To these criticisms we may anticipate that the advocates of rapid transit will raise the objection that the coefficients of resistance of the high-speed coaches they propose to build will be very much lower than those of existing railway coaches; and that, although it may be quite true the consumption of power varies with the cube of the speed, the use of a very much lower coefficient, by suitable design of the coaches, will bring down the cost to less than it is at present. Granted without hesitation that the adoption of a form of coach with smooth sides and pointed ends will bring down the coefficient of resistance to a very low figure. But if it will bring it down for high speeds it will also and equally reduce it for low ones. If it is possible to produce an efficient coach for transit at high speeds it is much more easy to produce one for low speeds. Yet, where is it? Our railway companies, with all their years of experience, have not been able to combine safety and convenience with any greatly reduced coefficient of resistance. If rapid transit engineers know of a comfortable and commodious design of railway carriage which has a coefficient of resistance less than one-fifth of that of existing railway coaches, let them produce it and run it at existing speeds on existing railways. There is a fortune awaiting them if they can.

THE PRACTICAL MEASUREMENT OF ALTERNATING ELECTRIC CURRENTS.

BY PROF. J. A. FLEMING, F.R.S.*

(Continued from page 451.)

II.—*The Measurement of Alternating Current Pressure.*

Before proceeding to discuss the various types of practical instruments for measuring alternating current pressure, it is necessary to pay attention for one moment to a distinction between electric circuits. I shall have to employ frequently the phrases inductive and non-inductive circuits, and I wish you to be perfectly clear as to the exact meaning of these terms.

Every electric conductor has the property of producing a dissipation of energy when an electric current is passed through it, and it has also the property, as a natural consequence of the above fact, of producing a fall in pressure in the current passing through it. If we consider for one moment a continuous current flowing through a conductor, then if by suitable means we measure the potential at both ends of this conductor, we find there is a fall in potential, or, as it is called, a drop in pressure down the conductor. The number by which we must multiply the strength of the current in amperes to obtain the fall in pressure measured in volts is the numerical measure of the resistance of that conductor measured in ohms. The rate at which energy is being dissipated in that conductor is numerically measured in watts by the product of this resistance and the square of the strength of the current. So far, all is simple when we are dealing with unvarying currents. If, however, we are using alternating currents then we should not find that the product of the resistance of the circuit and the $\sqrt{\text{mean-square}}$ value of the current gave us always the $\sqrt{\text{mean-square}}$ value of the drop in volts, neither would it be always true that the product of the resistance of the circuit and the mean-square value of the current would give us the mean value of the power taken up in that circuit. In other words, the drop in volts which would actually be observed in the case of an alternating-current circuit, especially if it is a circuit wrapped round iron, is more than can be accounted for by the simple resistance of the wire. We find we have in this case to take into account another quality of the circuit, which is called its self-induction. In the case of such a circuit the number by which we have to multiply the $\sqrt{\text{mean-square}}$ value of the current to obtain the $\sqrt{\text{mean-square}}$ value of the E.M.F. is the measure of what is called the impedance of that circuit. We can always measure the resistance of a circuit by means of a Wheatstone's bridge, and if taking any circuit we find that when an alternating current is passed through it the ratio of the $\sqrt{\text{mean-square}}$ value of the drop in volts down that circuit, to the $\sqrt{\text{mean-square}}$ value of the alternating current flowing in that circuit is greater than the true resistance of that circuit, such a circuit is called an inductive circuit, and the above ratio is a numerical measure of its impedance. I can best illustrate this by an example. Two wires, one of platinoid and the other of manganese steel, were wound into spirals round a wooden frame. Each of these wires was about 25ft. long, and made 40 turns round the frame. In the first place a continuous current was passed through each wire, and the fall in volts down each wire carefully measured, the magnitude of the current in both wires being 0·802 of an ampere. The drop in volts down the platinoid coil was 67·9, and down the manganese coil 79·7 volts. Accordingly the ratio of volts to currents in the first place is 84·66, and in the second case 99·38. This being done, an alternating current of the same $\sqrt{\text{mean-square}}$ value, as measured by a Kelvin balance, was passed through the two coils. The fall in volts down the platinoid coil was found to be 68·5, and down the manganese steel coil 80·7. These were the mean-square values. The ratio of volts to current in the first case is, therefore 85·41, and in the second case 100. These, therefore, are the impedances of these coils, and it is seen that in each case the impedance exceeds the resistance. The frequency of this alternating current was 108, and therefore these coils form slightly inductive circuits. I shall point out presently the manner in which practically non-inductive circuits may be obtained; but meanwhile it is sufficient to remark that if an iron core had been inserted in either of these coils, it would have greatly increased the impedance of that coil. It is always possible, however, to ascertain whether the impedance of a circuit differs from its resistance in numerical value. If it does not to any sensible extent, then the circuit is called a non-inductive circuit. If the impedance is greater than the resistance then the circuit is called an inductive circuit. There are many cases in which inductive circuits cannot be employed, but in which we must secure, by some means or other, a practically non-inductive circuit. Such a non-inductive circuit can be formed of a series of incandescent lamps, and for larger currents it can most conve-

* Abstract of Cantor Lecture delivered before the Society of Arts.

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niently be obtained by using rods formed of a mixture of plumbago and fire-clay, mixed in proper proportions to secure the necessary resistance, and then baked.

Turning now to the question of the measurement of alternating-current pressure, we will consider the various types of instruments which can be used for this purpose. In the first place, any one of the class of electro-dynamometer instruments or electro-magnetic instruments described in my last lecture, which can be wound with very fine wire, so as to make a current-measuring instrument of high resistance, can thereby become an instrument for the comparison of alternating-current pressure, provided that certain precautions are employed. In the first place, we may make a high-resistance dynamometer by winding a dynamometer with a wire of high specific resistance and of necessary length. The impedance of this instrument is, therefore, a fixed quantity, provided that we are dealing always with alternate currents of the same frequency. The indications of the instrument are indicative of $\sqrt{\text{mean-square}}$ value of the current flowing through it; and hence, by what has been above said, as to the definition of impedance, it follows that the $\sqrt{\text{mean-square}}$ value of the alternating-current pressure at the terminals of the instrument will also be given by the instrumental reading. In other words, we can take such a high-resistance dynamometer, and can graduate it for alternating pressure to any given frequency; but if the dynamometer has an impedance which differs sensibly from its true resistance, then, if calibrated for alternating currents of one frequency, it will not, in general, be identical in its indications for alternating currents of different frequency. We can, however, nearly always secure the condition that the impedance of such an instrument shall differ by very little from its true resistance, and then, when once it has been calibrated, by testing it with known unvarying pressures, it will enable us to measure alternating-current pressures, giving us their $\sqrt{\text{mean-square}}$ values.

In order to obtain the necessary non-inductive quality in such an instrument it is generally necessary to place the greater part of the resistance of the instrument in the form of a non-inductive coil of platinoid wire, which is placed outside the instrument, and then to a considerable extent we may be sacrificing sensibility. The same statements are true with regard to the employment of the electro-magnetic principle in the construction of alternating-current voltmeters. In all the instruments described in my former lecture Siemens dynamometers, the alternating-current ammeters made by Nalder, Evershed, Elihu Thomson, and Dobrowolsky, can be converted into alternating current voltmeters by winding them with very high resistance wires, putting that resistance in the form of a non-inductive resistance associated with the measuring part. In Evershed's current volt-ammeter there is a compensation for frequency which is worth noting. The voltmeter coil has placed in series with it a coil, the terminals of which are shunted by a condenser. This shunted condenser has the property of neutralising the self-induction of the voltmeter coil, and if properly adjusted, the instrument may be made to give identical scale indications for alternating pressures of widely different frequencies, and be practically compensated for frequency.

Turning, then, to the instruments for the measurement of alternating electromotive forces in which the thermal principle is employed, we have, first, the well-known Cardew voltmeter as a typical instrument for the measurement of such alternating pressures. In this instrument a platinum silver wire, of about 300 ohms resistance, is stretched in a tube, and, for the sake of compactness, the wire is folded backwards and forwards four times over small ivory pulleys. One end of this wire is fixed, and when a current is sent through the wire it becomes heated, and it attains a final temperature if the current passing through it is constant. The wire, therefore, elongates, and the expansion of the wire is measured and detected by a multiplying gear of the following kind. The elongation of the wire is made to cause a revolution of a mechanism consisting of an intergear of wheels and pinions, and to the last axis of the series an indicating needle is attached, moving over a divided dial. The wire has to be held in a tube or frame, and there are two types of this instrument, called respectively the rod and the tube type. In the rod type of instrument, which is the easiest to manufacture, the platinum-silver wire is kept extended by being fastened to two rods, formed one-third of iron and two-thirds of brass. The whole instrument is then enclosed in a brass case. When the current is passed through the wire it heats it, and the rods become heated also by radiation from the wire. It takes a certain time before the rods settle down into a final state of temperature, in which the heat received by them is equal to the heat radiated by them. Until this is the case, the instrument does not come to its final reading. In the other type of instrument, called the tube instrument, the wire is attached simply to the brass and iron tube, which forms the case of the instrument. In this latter type the outside tube arrives very much more quickly at its final state of temperature, and hence the instruments of the tube type are preferable for accurate work on account of the fact that they thus come much more quickly to their final readings when put upon the circuits. The Edison-Swan Company manufacture a type of Cardew voltmeter which is easier to string than the ordinary tube instrument, and yet has all the advantages of that instrument. Another disadvantage which the rod instrument possesses is that there is generally a considerable negative variation of the needle on taking off the current. The rods do not cool as quickly as the wire, and, therefore, when the current is taken off, the needle goes back beyond the zero of the scale. The instruments are generally made for reading pressures from 40 to 150 volts. In the manufacture of the instruments the wire has first to be carefully aged by putting current on and off for some time at intervals of one minute, so as to heat and cool the wire. In this way a certain variation in expansion is got rid of, and the platinum-silver wire is brought into a condition in which it always is the same length and the same temperature. These Cardew voltmeters are really of course alternating current ammeters which take a current of about one-third of an ampere at 100 volts. The instrument of this range therefore dissipates a power of 30 watts, and, as I shall point out later on, has the disadvantage of wasting a considerable amount of energy if kept continuously upon the circuit, but when carefully made the Cardew voltmeter is an instrument of great value for measuring alternating current pressure. A special form

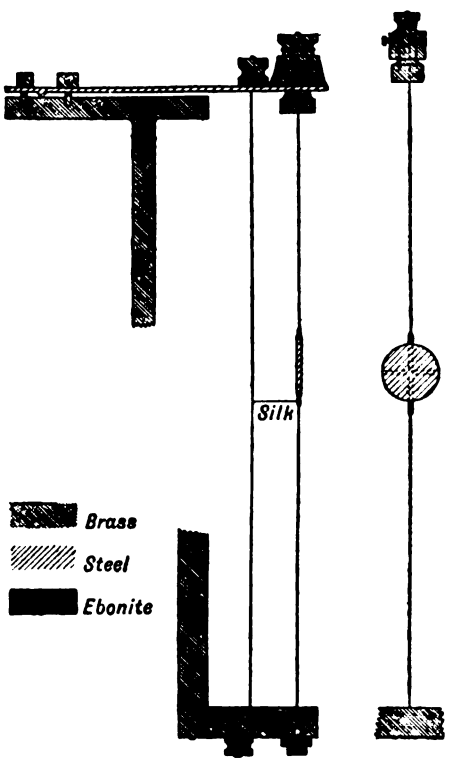

FIG. 9.

of this Cardew voltmeter is also made by the Edison-Swan Company for engine-room purposes, the dial of which is very large, and which is graduated say from 80 to 110 volts. In this way such a graduation is given to the instrument that a variation of one volt can be easily seen at a considerable distance. There are some modifications of the Cardew voltmeter which are useful in measuring very small alternating E.M.F., such as the voltmeter of Major Holden. In this instrument a short and very fine platinum silver wire is stretched between two supports, and it is kept sagged in the middle by means of a small spring (*see* Fig. 9). To the centre of the wire is attached a thread, also attached at the other end to the side of a small mirror. If the sag of the wire increases or diminishes, the mirror is more or less pulled round. When a current is passed through the wire it heats it. The sag increases and the mirror is moved. This instrument will measure without an external resistance from nothing up to two volts conveniently, and by putting the external resistance in series with it, and by employing a long ray of light the instrument can be made to indicate pressures of any required voltage with great accuracy. Major Holden has converted the above-described instrument into a useful self-registering voltmeter making a photographic record of variation in pressure. This is achieved by letting the ray of light reflected from the mirror fall upon a revolving drum covered with photographic paper. The drum turns round by clockwork once in 24 hours, and the ray of light marks a photographic record of the revolving paper by which any variation in the pressure is detected and measured. A similar low voltage thermal

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voltmeter is constructed for use with secondary batteries for measuring the E.M.F. of each cell. In using such thermal voltmeters it is necessary to avoid convection currents of air in the enclosing tube or case. In using a Cardew voltmeter it is generally found best to place the instrument with the tube horizontal. In this way the variable cooling effects of the air currents in the tube are, to some extent, prevented. If a Cardew voltmeter is used with its tube vertical, the needle will be observed to make small movements to and fro, even if the current is perfectly steady. These movements of the needle may, if they occur, prevent the pressure from being accurately read within less than one volt.

We must now pass on to notice instruments for the measurement of alternating pressure which depend upon electrostatic attractions. These electrostatic instruments have for many purposes very great advantages, the most notable of which is that they do not consume power, and that, therefore, they may be left on the circuits indefinitely without cost. The first of these instruments which I will describe is Lord Kelvin's electrostatic voltmeter for high pressures. It consists of four quadrant-shaped plates which are connected to one terminal of the instrument. Suspended between these plates, but insulated from them, is a paddle-shaped aluminium needle, which swings on very delicate pivots. The needle is connected to the other terminal of the instrument. The instrument, in fact, forms a condenser, of which one plate is fixed and the other is movable. When a difference of potential, varying from 1,000 to 5,000 volts, is produced between the terminals of the instrument, the movable plate is attracted in between the fixed plates. This movement is resisted by weights, which are hung on the bottom of the needle. When two plates, in fixed positions, have produced between them a difference of potential, the force required to hold them in any given position is proportional to the square of the difference of potential between them. To the end of the aluminium needle is attached a long pointer, moving over a divided scale, and the instrument is graduated in such a manner as to read directly in volts. Since the attraction between the plates depends upon the square of the potential difference, it is independent of sign, and therefore the instrument works equally well with direct or alternating pressures; and, in this latter case, it gives us the $\sqrt{\text{mean-square}}$ value of the potential difference between the terminals of the instrument.

Another instrument, also invented by Lord Kelvin, but adapted for measuring lower pressures, is the multicellular electrostatic voltmeter. In this instrument there are a series of quadrant shaped plates placed one above the other, which are called cells. There are then a series of paddle-shaped needles, all attached to a common axis, which is hung up by a platinum silver wire. The normal position of the needles is just outside the quadrants, but if a difference of potential is created between the needles and the cells, and the needle is drawn or attracted into the cells, this movement is resisted by the torsion of the suspending wire. An indicating needle, attached to the axis, moves over a divided scale; and the instrument, which can be arranged to measure from 40 volts upwards, gives us, therefore, the $\sqrt{\text{mean-square}}$ value of the potential difference between the cells and the needle.

In these instruments there may be a very small error in reading, which is dependent upon the existence of a small E.M.F. of contact between different metals. If the cells are made of brass and the needle of aluminium, there is a small contact difference of potential, which is due to these different metals, and which may amount to something less than half a volt. Accordingly, it will be found that in such an instrument, reading, say, 100 volts, the reading given by the instrument will depend upon whether the cells are positive or negative, and a small correction has to be applied, depending on the manner in which the instrument has been joined up in calibrating it. Similar instruments for measuring potential differences of much larger amount have been invented by Lord Kelvin. In these instruments the electrostatic attractions between two plates are balanced by the gravity of a weight. One of the plates is a fixed insulated plate, and the other a movable plate hung on a balance arm. The movement of a needle over a scale indicates the pressure in volts. Instruments similar in principle to the above have been devised both by Prof. Ayrton and Mr. Swinburne. In both these instruments the same principle is employed. There is a fixed insulated plate, and a movable plate to which is attached a needle. The electrostatic attractions between these plates are made to move the needle over a divided scale. Lord Kelvin has also devised a form of multicellular voltmeter which is useful for central-station purposes as it has a vertical scale, and the instrument is intended to be attached to a switchboard. I may now point out the advantage of these electrostatic instruments to which I referred a moment ago. Take, for instance, a thermal voltmeter absorbing 30 watts, and assume that this instrument is kept connected to the circuits in the dynamo room of a central station all the year round. Since there are, roughly, 8,000 hours in a year, this instrument, absorbing 30 watts, would in one year dissipate 240 Board of Trade units of electric energy. If we reckon this energy as costing 1d. per unit, it is evident that this instrument will cost 240d., or £1 per annum, to keep it going. In reading alternate-current pressures higher than 100 volts, a transformer has to be interposed between the circuits and the voltmeter, to reduce the pressure. This transformer will also use up energy, and if it takes no more than the voltmeter, it will also waste £1's worth of electric energy in the course of a year. We see, therefore, that an electrostatic instrument which wastes no energy at all is, in cost of up-keep, much superior to the electro-thermal or the electro-magnetic type of instrument; and, in fact, we can afford to spend a great deal more on an electrostatic instrument, and yet effect a total saving in the cost of the electric measurements in that station. For suppose we capitalise our £1 at 10 per cent., we can then afford to spend £10 more on an instrument of the electrostatic type than one of the electro-thermal or the electro-magnetic type, which wastes no more than 30 watts if we keep them on the circuits always. There is, therefore, every reason to believe that in course of time electrostatic instruments for the measurement of pressure will entirely supersede instruments of the electro-thermal or electro-magnetic type in all those cases in which the instruments have to be kept upon the circuits constantly. We may employ these electrostatic voltmeters for the measurement of alternating currents, and convert them into alternating-current ammeters in the following way. Let a non-inductive resistance, say of platinoid wire, be constructed which is capable of passing without sensibly heating the current to be measured, and let the resistance of this wire be accurately known. Then to the ends of this circuit attach an electrostatic voltmeter. Knowing the difference of pressure between the ends of the resistance and its resistance, we know the current flowing through it. In many cases, as in measuring the primary currents of a transformer at no load, it is much more convenient to employ such an electrostatic voltmeter and non-inductive resistance than any other method. Suitable non-inductive resistance can always be made by coils of platinoid wire, joined in parallel; and these must be so adjusted that the final temperature they attain is not more than a few degrees above the normal temperature.

(To be continued.)

ON THE ELECTRIC LIGHT OF LIGHTHOUSES.*

BY ANDRÉ BLONDEL.

With the object of improving, if possible, its installations, the Lighthouse Department of France has undertaken, on the initiative and under the direction of M. Bourdelles, Inspector-General, since 1891 a series of systematic experiments, which have had reference to the use of both continuous and alternate currents. The results have already been summarised in the notice on lighthouse apparatus presented by this Department to the Chicago Exhibition. I propose here to explain in more detail the investigations that have been made with the two varieties of current at the lighthouse establishment, and at the same time the considerations that weigh in favour of each solution.

In a certain number of old lighthouses two grades only are used—a single and a double light—one, as the term implies, corresponding to double the intensity of current of the other. In French lighthouses of the old type these intensities are respectively 50 and 100 amperes. In the English lighthouse of St. Catherine they are 175 and 350 amperes, They are obtained by supplying the lamp either with one of De Méritens' machines, type G or L, or with two coupled in parallel circuit. But the gradation so obtained is imperfect, because the reduction of range due to atmospheric absorption varies in a much greater ratio than that of 2 to 1, when the weather changes from moderately clear to foggy. In average weather—that is to say, for about 20 per cent. of the year—on the French coast of the Channel and the ocean, a current of 25 amperes is more than sufficient, with bifocal apparatus, to enable the geographical range to be attained, and even surpassed. In the flashing apparatus, "feux-éclairs," an illumination is realised which reaches to 85 miles, whilst in foggy weather a double intensity corresponding to a current of 100 amperes only reaches 26 miles. In these conditions it is necessary that the intensity of the current should vary at least from 1 to 4, and that the weaker currents, which are the most used, should be obtained with suitable efficiency. In French lighthouses the two extreme currents are 25 and 100 amperes. Many combinations may be made to obtain intermediate gradations.

Arc lamps, as we know, have their mechanism in the lower part, and rest directly on the platform (Fig. 1), of the optical apparatus. Their principal function is to constantly bring together the carbons as they are consumed. Some of them have a striking arrangement which automatically separates the carbons to start the arc. But none of them in ordinary working can increase the distance of the carbons if they have accidentally come too close to each other. In

* Abstract of a Paper read at the International Maritime Congress, London meeting.

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that respect an improvement might, perhaps, be introduced, but we can avoid the cause of too near an approach by suppressing, as we shall see later, the variations of the current.

The lamps for alternate currents (Fig 1), almost the only ones at present used, all belong to the original Serrin type, or to that type modified in certain points of detail by MM. Berjot, Le Baron, Ciolina, &c. The movement of approach, which is made under the action of the weight of the upper carbon-holder, is governed by clockwork, with an escapement put in play by an electro-magnet when the distance becomes too great.

The necessity of reducing the heating effect on the magnet and the change of attractive force that arises with the change of current has led for some time to the abandonment of the practice of putting the electro-magnet in series with the principal current. In the new French lighthouses we send, whatever the main current may be, the current of half of one of the machines of De Méritens through the electro-magnet; the remainder goes directly to the lower carbon by another cable. This method, which requires three cables, complicates the installation and the construction of the switch-board, although care may be taken to connect all the commutators of this board so as to enable the change of current to be made by one operation. It is more natural to employ, as in the lamps of Le Baron, an electro-magnet placed in a shunt and wound with fine wire. The number of conductors is reduced to two, and there is no further need to split up the machine circuit.

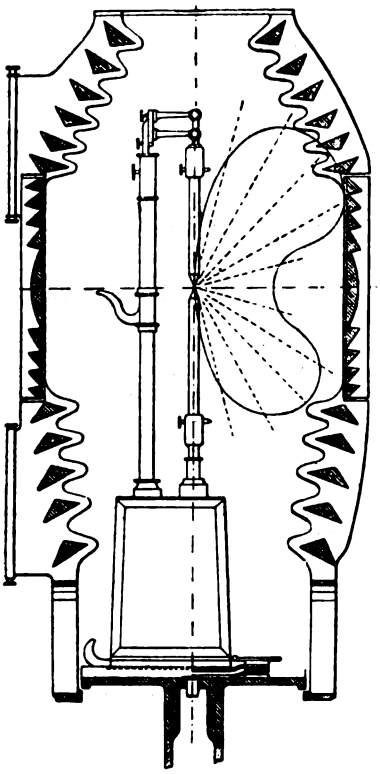

Fig. 1.

The same type of regulator might also well be applied to continuous currents. Messrs. Sautter and Harlé have preferred to adopt for the experimental lamps of the lighthouse of La Hève a type analogous to that of the projectors (Fig. 2), in which the approach of the carbons is produced by a screw passing through the two carbon-holders, and operated by an electromotor through a rachet. The latter receives a shunt from the principal current through a relay controlled by a small electro-magnet placed in shunt across the terminals of the lamp. Each movement of the screw is accompanied by a similar movement of rotation of the socket of the lower carbon-holder so as to regulate the shape of the carbons. But this movement is too slow to produce a favourable result. The principal advantage of this lamp consists in the employment of a solenoid placed around the lower carbon, of which the purpose will be later explained. With the present lamps the regulation of the arc so that it may occupy the focus of the apparatus is effected, as is well-known, by the aid of a screw that raises or lowers the two carbons simultaneously. The attendant constantly moves this screw so as to bring the image of the arc or of one of the carbons to a mark traced on the table. There would evidently be an advantage in producing this movement automatically, but the attempts made in this direction have not been sufficiently satisfactory to lead us to pursue them further. An automatic system would also have the disadvantage of not requiring the attention of the attendant, which it is as well to stimulate.

It appears to be established that the arc consists of a current of carbon reduced to a state of vapour at the surface of the positive pole, which assumes the form of a crater; owing to this circumstance the positive pole constitutes the most brilliant part of the electric arc. It is estimated that it furnishes more than 85 per cent. of the light produced, while the negative carbon give less than 10 per cent., and the arc, properly so-called, less than 5 per cent. The temperature of volatilisation of carbon being a physical constant, the temperature of the crater must be invariable for a given carbon, and consequently also its intrinsic brightness (that is to say, per unit of surface). The experiments of Messrs. Abney, Rosetti, and Violle, &c., have shown that this is correct. But this law is only applicable to the maximum brightness; in fact, this maximum is only produced on a variable portion of the crater, and the mean brightness of the crater may vary within wide limits (that is to say, the total light that it emits divided by its total surface). In the experiments made in 1878 at Chatham by Royal Engineer officers it was found that the mean brightness may vary from 26,000 to 76,000 candles per square inch. I have also observed similar variations.

Distribution of the Light.—The power of a pencil of light produced by a luminous source placed in a given apparatus only depends, as we know, on its mean brightness and the geometrical form of the apparatus, and on the surface of the latter usefully illuminated. In the present case the useful parts are those which receive the light of the crater. The well-known form of the curve of distribution of the arc light from continuous currents (Fig. 3) shows the unsymmetrical fashion in which this light is distributed; and Mr. Trotter has recently proved that in every direction the quantity received is nearly proportional to the portion of the visible surface of the crater. It thus appears that above the horizontal plane through the edges of the crater the electric arc is of no great service.

Arrangement of the Carbons.—In placing in our present apparatus the positive carbon above the negative, as was done in the

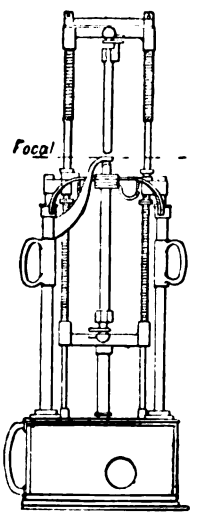

Fig. 2.

first applications, notably at the Lizard (England), the most important part of the apparatus was not made use of. Sir James Douglass proposed, in order to overcome this difficulty, to place one of the carbons eccentrically, so as to produce an oblique crater similar to that of projectors. But this arrangement, which only illuminates the apparatus over a very limited part, is unsuitable for lighthouses in the generality of cases. It has, then, been attempted to place the positive carbon below and the negative above, but a further difficulty is then met with. The arc which with the crater above finds itself, so to speak, kept in place by the latter, now begins to travel round the edges, is uncertain, and is easily extinguished. This difficulty, not important with small lamps, becomes so serious with currents of more than 50 amperes, that it has hitherto completely hindered the employment of continuous currents. An attempt made in this direction at May Island (Scotland) in 1886 proved disappointing.

Messrs. Sautter, Harlé and Co. have recently overcome the difficulty by a very ingenious application of electro-dynamic action; for this purpose they arranged concentrically to the lower carbon (Fig. 2), and as near as possible to the arc, a solenoid formed of several turns of thick copper wire traversed by a shunt from the current of the lamp and protected by a refractory plate; the arc, behaving like a fluid conducting body, begins to turn around its own axis with a very rapid movement, as was shown by an instantaneous photographic record, and immediately obtains, in virtue of its gyration, a great stability. The regularity

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in the shape of the carbons is favoured in some measure by the slow movement of rotation given as described above to the lower carbon. It is with a Sautter-Harlé lamp of this system that the experiments have been made at the lighthouse establishment, and will be pursued at the lighthouse of La Hève. It might be well to adopt it for continuous currents, if we had to preserve the present forms of lamps and apparatus. In this case all the part of the optical apparatus below the focal plane not seeing the crater ought to have as its focus the point of the negative carbon. It would even be better to suppress it completely, and give to the cupola a larger development in diameter and in height, as was done for the apparatus of the Isle of May, where the only thing objectionable was in replacing by catadioptric rings the upper half of the dioptric drum. Under these circumstances it might perhaps be advantageous in certain respects to turn round the half apparatus, giving it the arrangement shown by Fig. 3. We might then replace the ordinary lamp by a lamp suspended to the upper part and analogous, save as regards power, to those employed in public lighting, in adopting for carrying the lower carbon a single rod placed on the land side,

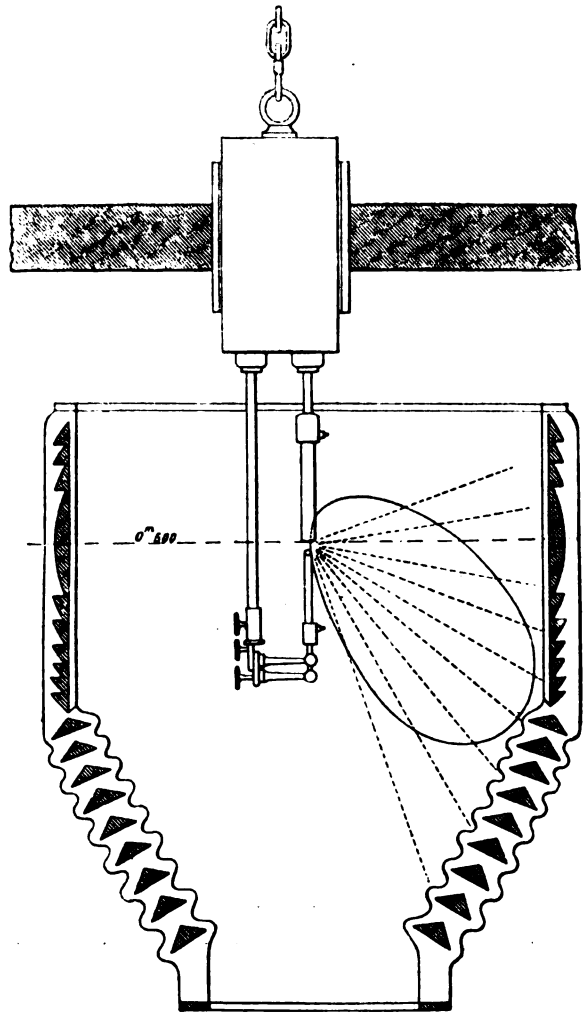

FIG. 3.

the lamp might be put in a case fixed to a small footbridge accessible to the attendant, and its replacing could be effected almost instantaneously, without any need of stopping the apparatus of rotation. Thanks to the employment of a positive carbon above, we should obtain a suitable condition of the arc more easily than now. Lastly, in giving to the apparatus a diameter of 1 metre in place of 0·60 metre, for example, we should amply compensate for the loss of useful surface due to the suppression of a part of the drum and of the ring, and should restore the horizontal divergence to a value nearly that which it has at present.

Useful Effect Obtained with Different Currents.—With arcs which are geometrically similar (that is to say, in which the proportion between the distance apart of the carbons, the diameter of the carbons, and the square root of the intensity remains the same), the occultations of the crater by the negative carbon have the same relative value. We must, then, always obtain the same optical effect at a great distance, and there would be no advantage in employing arcs of great intensity. In practice this somewhat hasty conclusion is contradicted by experience, as is shown by the following table, in which are collected results obtained from experiments made with similar continuous-current arcs :—

Apparatus.	Diameter of carbons. Upper	Diameter of carbons. Lower	Intensity of current in amperes.	Pressure at the terminus in volts.	Power expended in watts.	Mean minimum power in carcels (carcel = 10 c.p.).	Luminous efficiency per watt in carcels.
	mms.	mms.					
Bifocal (type, 1888)	10	13	25	50	1,250	411·	·329
,,	18	22	75	53	3,975	661·8	·167
,,	18	25	90	52	4,680	900·	·192
Feu-éclair bifocal apparatus of La Hève	13	13	25	53	1,325	637·	·481
,,	18	21	47	55	2,585	916·	·354
,,	21	23	98	50	4,900	1,300·	·265
,,	18	23	94	57	5,358	1,781·	·332

This apparent contradiction might be explained by the small extent of the luminous surface compared to the inevitable aberrations. Further, we must not forget that when the maximum brightness is constant the mean brightness of the useful incandescent part may be variable within certain limits, as was said above.

Separation of the Carbons.—The minimum distance apart which enables us to obtain from arcs of 25 amperes and upwards a light free from hissing is from 4mm. to 5mm., corresponding to a pressure of 45 volts at the arc and about 50 volts at the lamp terminals. There is an advantage with regard to optical efficiency in increasing the distance a little until the crater is completely free without passing the limit at which the arc becomes unstable and produces too much flame.

Properties and Effects of the Alternate-Current Arc.—The arc produced by alternate currents results from a transport of carbon, no longer continuous and constant, but variable and alternate.* At the same time that the direction of the current changes, the arc is extinguished in a more or less gradual manner.† This extinction is not perceptible to the eye above a frequency of 40 per second; but, below this value, it produces a barely perceptible twinkling. As it is difficult to obtain alternators of small power and of slow speed giving a high frequency, we should be content with a frequency not much larger than this minimum. It will be seen later that no inconvenience arises from this in respect of the intrinsic brightness.

To produce an alternate-current arc with a frequency of 50, the minimum pressure of about 25 volts need only be attained or surpassed during a fraction of the alternation of something like half; the average pressure is then lower than that for the continuous current arc. A lighthouse arc requires, length and intensity being equal, an alternate current of 45 volts instead of a continuous current of 50 to 55.

The true power (P) expended in an alternate-current arc is always less than the apparent power (E I). The ratio of these two quantities, according to numerous measurements which I have made with the help of the wattmeter, or by means of the periodic curves, stands on an average at the following figures for arcs whose frequency is 50 :—

Arc.	Coefficient of power, $\frac{P}{E I}$.
Steady and silent	0·90 to 0·95
Noisy and unsteady (with a separation of 2 to 5 millimetres)	0·85 to 0·90
Hissing and striking.....	0·75 to 0·80

Conditions of Steadiness.—The steadiness of the alternate-current arc requires, in addition, that the available electromotive force employed should be sensibly superior to the difference of potential at the terminals, either because the arc behaves during each infinitely small period of time just like a continuous-current arc, or because after each extinction an increased pressure is necessary to relight the arc. Numerous experiments have shown that for a lighthouse arc of 25 amperes and 45 volts with hard carbons, such as those described later on, it is necessary to have at command an induced electromotive force of at least 60 volts.

* In the first "Alliance" machines the currents were rectified by the aid of a commutator; the arc was not then alternate, but simply intermittent.

† A complete study of these phenomena will be found in two other works—*Lumière Électrique*, Vol. XLII., December, 1891; Vol. XLIII., January, 1892, &c.

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In order to bring back the pressure at the terminals of the lamp to 45 volts a resistance is no longer interpolated, but self-induction, which, while giving more elasticity to the arc, does not absorb energy. This being so, there is nothing to prevent the employment of an electromotive force of 75 to 85 volts, and obtaining by this means exceptionally steady arcs, which relight of themselves when they are blown out or extinguished.

Distribution of the Light.—Thanks to the form of the points of the carbons, the light can be directed almost equally to all parts of the lenses in contradistinction to what occurs in the case of continuous currents. The form of the curve of light distribution given by M. Allard* is only applicable to arcs of very small length. It would probably be suitable to the arc light of St. Catherine (Isle of Wight), the separation in which is not more than $\frac{1}{2}$mm., and the pressure only from 35 to 38 volts. With an arc so short, almost always on the point of sticking together, the surfaces of maximum brightness are almost completely shaded by the carbons, and it seems hard to believe that the highest efficiency could be realised in this way, as some have asserted.

In France it is preferred to employ a genuine arc, with a pressure of 45 volts, corresponding to a separation of 4 to 5 mm. for the current of 25 amperes, and exposing the bright surfaces. The part played as a lightning agent by these is then shown by the curve of light-distribution, which assumes the appearance of a butterfly (Fig. 1), giving maxima in directions having an inclination of 45deg., the superiority of which over the horizontal intensity becomes more marked as the separation is made greater.

Intrinsic Brightness.—It would seem that the maximum intrinsic brightness ought to be less than in the case of the continuous-current arc, since each surface only acts as a positive pole during one alternation in every two, and even less, and can thus cool during the remainder of each period. As a matter of fact, this is the case with arcs of very small intensity (8 to 10 amperes). But in those of 25 amperes and upwards, the period of extinction being very short, and each crater being smaller than the average intensity would require, the measurements made with the Le Chatelier pyrophotometer at a frequency of 50 have not shown any appreciable difference. The maximum brightness does not even vary to any extent with the intensity or with the separation. But the same reservations, as in the case of the continuous current, must be made as far as the average brightness is concerned.

Practical Effect with Different Currents.—To appreciate the ultimate effect in the optical apparatus, we come back, then, once more to the question of occultations. The bifocal arrangement devised by Inspector-General Bourdelles, which consists in placing the focus of the dioptric drum (Fig. 1) at the centre of the incandescent part of the lower carbon, and the focus of the catadioptric rings at the centre of the incandescent part of the upper carbon, theoretically allows of nearly all the focal rays of the apparatus passing by the surfaces of maximum brightness. But in practice this maximum efficiency is not realised, owing to inevitable occultations, and to an effect analogous to that already pointed out in the case of continuous currents. The power of the pencil still increases with the intensity of the current, as is shown by the following table, which I borrow from the paper already quoted, only adding the column of true efficiencies :—

Diameters of the carbons.	Amperes.	Volts.	Apparent watts.	True watts.	Carcels of ten candles.	Efficiency per watt.
10	25	45	1,125	1,070	1,200,000	1,120
16	50	45	2,250	2,140	1,800,000	840
25	100	45	4,500	4,275	2,300,000	512

The explanation of this phenomenon might be sought in the same causes as in the case of continuous currents. However that may be, as the luminous power only increases slightly in comparison to the expenditure of energy, there could be no advantage in going further in this direction, and it would be preferable, in accordance with the curious observation of M. Bourdelles, to unite several lights of small intensity in separate lenses.

However, if we have to employ later on lenses of greater diameters (3rd, 2nd, and 1st order), the period of brightness being less than the maximum time of perception, all the light would be utilised; and even admitting that the brightness would remain the same, there would be an advantage in increasing, within certain limits, the power of the arc.

Choice of Carbons, Diameter, and Separation.—For the same reason as with continuous currents, we employ the hardest possible carbons. The specific resistance of "Carré" carbons, which give excellent results, increases with the diameter; it may be estimated on an average at 7,000 to 8,000 microhms. The smallest admissible dimensions, and consequently the most satisfactory, are indicated in the preceding Table. They correspond to currents of 0·315, 0·25, and 0·24 amperes per square millimetre.

This current density might be further increased, and consequently the diameter diminished, by the employment of carbons lightly coated with copper ($\frac{1}{10}$th of a millimetre), so that the melting of the copper may not produce any accidental shunt circuit, followed by extinction.

The arc cannot be made longer than 10 to 15 millimetres without producing a large flame. Geometrically it appears sufficient to separate the parts raised to the maximum brightness until the distance is equal to half the diameter of the terminal faces, or about a quarter the diameter of the carbons, that is to say, to 6 millimetres for arcs of 100 amperes. The two foci of bifocal lenses being at 1cm. apart, we are thus assured that the focal rays pass through the incandescent portions. The corresponding pressure, which is about 45 volts, has been allowed for all the currents in order not to complicate the service whilst realising the maximum power of the De Méritens machines at the speed of 550 revolutions. To determine directly the best distance between the carbons, a series of experiments should be made with the same intensity of current. The measurements made on this point at the Lighthouse Department (France) have only availed to establish that in bifocal lenses, and with magneto machines, the actual currents were higher than those that would be obtained by increasing the separation, as the following table shows :—

Diameter of the carbons.	Distance apart.	Intensity.	Pressure.	Electric power.		Luminous power.	Efficiency per watt.
				Apparent.	Corrected.		
mm.	mm.	amperes.	volts.				
16	5	50	45	2,250	2,140	1,925,000	900
16	15	45	50	2,250	2,140	1,140,000	532
10	4	25	45	1,125	1,069	1,110,000	1,032
10	6	23	47	1,080	1,026	1,014,000	980
10	8	19	52	988	939	720,000	771

But these conclusions would not necessarily apply to different types of machine or optical apparatus.

Comparison of Continuous and Alternate Currents.

This comparison, the elements for which have been furnished in the preceding chapters, should refer at once to the arc, the optical apparatus, and the dynamos.

1. *The Dynamos.*—The continuous current dynamos are satisfactory from the point of view of strength and safety. They show great economy in space and in cost compared to the De Méritens machines, but the steadiness of the arc has only been obtained at the cost of a loss of efficiency, the efficiency at the terminals of the lamp having been reduced to 0·58 or 0·65 at the 25 and 50 ampere currents.* On the contrary, the new alternators allow us to preserve the advantages of the De Méritens machines while costing a little more than the dynamos, and giving electrical efficiencies of 74 and 80 per cent. at the two currents considered. It is these machines, then, which appear at present likely to take the place of the De Méritens machines without any change in the remainder of the service.

But it is not to be forgotten that all the possible advantage obtainable from continuous current dynamos has not yet been obtained, and that by a suitable compounding we might probably realise a stability and efficiency superior to those hitherto obtained with these machines.

2. *The Arc.*—In spite of the ingenious solenoid of MM. Sautter, Harlé and Co., and the employment of the rheostat, the continuous current with the positive carbon below remains inferior in regularity to the alternate current arc. This may be seen from the following table, which sums up in a comparison the variations in illumination of the ray observed in the experiment of the central depot.

Variations in Arc Lights.

Apparatus.	Current.	Relative variations of the luminous power.		
		With current of 25 amperes.	With current of 30 amperes.	With current of 100 amperes.
Feu-éclair type, 1892	Alternate	Per cent. 30 to 36	Per cent. 40 to 50	Per cent. 50 to 70
Ditto	Continuous	142	165	187

* It is just to observe, nevertheless, that at the lighthouse of La Hève, where the definitive experiments will take place, the steadying resistances may be suppressed in large measure owing to the resistance of the cables.

* "Memoire sur les Phares Électriques," Plate I., Fig. 4.

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This inferiority is especially important with feux-éclairs, in which the lamp turns with the apparatus, and where it is consequently necessary that the figure should be as symmetrical as possible in order that successive flashes may be of equal power. The arc with positive carbon uppermost would give in this respect more favourable results.

3. *Apparatus.*—The present bifocal apparatus is combined for the use of the alternate current. Experiments made at La Hève (feu-éclair) with an apparatus of 0·60 metre in diameter, in four panels, have given, with almost equal currents, luminous powers and efficiencies much superior with alternate currents to those obtained with continuous currents, as is shown by the following table* :—

Intensity of current.	Continuous currents.			Alternate currents.			Ratio of luminous powers with equal intensity.
	Volts.	Luminous power. Carcels.	Efficiency in carcels per watt.	Volts.	Luminous power. Carcels.	Efficiency in carcels per watt.	
25	53	650,000	480	45	1,200,000	1,120	1·85
50	55	1,000,000	350	45	1,800,000	840	1·80
100	50	1,300,000	265	45	2,300,000	512	1·76

These figures are, as we said above, only the mean, and not the absolute values.

4. *Efficiency.*—The preceding table gives the efficiency measured at the lamp—that is to say, the number of becs per electric watt consumed by it. To have the definite efficiency—that is to say, the number of becs per watt of mechanical power furnished to the dynamo—we must multiply these figures by the value of the efficiency of the dynamo, including the rheostat. We thus obtain the following results in the conditions realised in the respective experiments :—

Current in amperes.	Efficiency of the De Méritens magneto.	Efficiency of the Sautter-Harlé dynamo with rheostat.	Luminous efficiency. Carcels.	
			Alternate current.	Continuous current.
25	0 52	0·58	625	278
50	0·73	0·65	615	227
100	0·73	0·65	374	172

The alternate-current is superior, then, by more than 100 per cent. to the continuous current, and the advantage would have been still greater if the new alternators had been employed. But the ratio of the luminous power obtained—a ratio which shows a remarkable constancy, and which is on the average practically equal to 1·80—only represents in reality the ratio of the surfaces of the apparatus usefully illuminated in each case, that is to say, the ratio of the total surface to the portion of surface situated above the focal plane. If we calculate the value of these surfaces we find their ratio is about 1·90, which confirms this view.

To obtain with the continuous current the same power as with the alternate current, it would then suffice to increase the surface utilised in the manner indicated above ; for example, in the monofocal apparatus of 1·00 metre diameter, represented in Fig. 3, we should realise a useful surface, about 1·3 times greater than that of the apparatus of La Hève.

Conclusions.—The comparison between the two systems will only be definitive when it takes into account more improved dynamos, and optical apparatus specially suited to each. *A priori*, it is difficult to say which will give the best efficiency in the end. It would seem, however, that the alternate-current arc will always keep its superiority, because of the smaller voltage with which it is satisfied when the separation of the carbons is equal, and because of the great steadiness of working of the alternators that feed it.

With equal efficiency alternate currents offer, besides, a greater facility for distributing the light below the horizon by the use of the bifocal form, and they permit the employment of a smaller and more symmetrical apparatus than does the continuous current.

Also in view of the entirely satisfactory results furnished by alternate currents, and the remarkable advantages shown by the De Méritens machines or alternators endowed with similar properties, the French lighthouse service has not thought well to go on with the use of continuous currents at present in the new optical apparatus. This path, is, nevertheless, open to the initiative of manufacturers.*

Résumé and Conclusions.

To summarise, in this investigation I have analysed the different conditions necessary to the successful operation of an electric lighthouse with continuous or alternate currents. As to the chief *desiderata* relating to the machines, to the lamps, and to the optical apparatus in each of these two systems, and the comparative results obtained by the lighthouse service in France, the conclusions of this investigation are as follows :—

1. The three elements constituting an electric lighthouse—machine, lamp, and optical apparatus—should not be studied separately, but taken together, in view of the end to be sought ; in particular, the lamp and the dynamo must be considered as two parts of one whole. 2. The best method to secure a good light service in ordinary conditions consists in uniting in each establishment two similar machines, each capable of furnishing two currents of 25 and 50 amperes. The employment of currents above 100 amperes would not be justified in the French "feu-éclair" apparatus. 3. The De Méritens magneto machine is particularly appropriate for this service, and the only serious objection to be raised against it is its comparatively high price. 4. The construction of a continous or alternate current machine, capable of replacing the magnetos, while preserving the same advantages, is not so easy a task as electricians are tempted to think it. The best proof of this is in the absolute or partial failure that has attended the efforts of manufacturers of repute in other countries as well as in France. 5. The attempts made have, nevertheless, shown the possibility of obtaining alternators suited to the service at a very moderate price, and of better efficiency than that of the magnetos, and perhaps at a later period continuous-current dynamos, having similar properties, by using a special method of compounding. The alternators will give us the safety and regularity that (continuous-current) dynamos will obtain with difficulty. 6. The comparative results obtained in the optical apparatus now in use show a considerable superiority in the alternate currents in respect of luminous efficiency. But these apparatus not being the best suited to continuous currents, it may be objected that an apparatus specially constructed for them might utilise the energy expended nearly to the same extent realised with alternate currents. However that may be, the latter exhibit at present advantages of all kinds which are of a nature to justify the preference that has been given them for lighthouse lighting.

* We have not quoted in this table the figures of 1,800,000 becs, or 332 per watt, mentioned above, for the current of 98 amperes at 57 volts, because the 500,000 becs of increase were only gained by the excessive diminution of the negative carbon (18mm. instead of 23), with which such a condition could not be maintained. It produces, also, too great irregularity ; the power varying from 580,000 to 3,200,000 becs, while in the normal *régime* the power only varied from 1,300,000 to 3,130,000 becs.

* MM. Sautter, Harlé and Co. have recently proposed a still more radical project, consisting in a Mangin projector revolving over a bath of mercury like the "feu-éclair."

† Abstract from the *Elektrotechnisches Echo*, July 15 and 22, 1893.

THE BOCKENHEIM ELECTRICITY WORKS.†

The Bockenheim Works, though of no great extent, are somewhat remarkable, as being the only station where alternate are transformed into direct currents before use. Bockenheim, although rejoicing in a separate municipal authority, is in reality only a kind of industrial suburb of Frankfort, and the chief consumers, therefore, are factories, a large number of which are of small size ; there is practically no private lighting. Local considerations pointed to a high-pressure system as necessary, and to a distribution so arranged as to be suitable for motors ; and the Lahmeyer alternate direct current-system shown at the Frankfort Exhibition was chosen as most suitable for the purpose, and the work was therefore entrusted to Messrs. W. Lahmeyer and Co., of Frankfort, who began in the summer of 1892, and started running in December. The engines are tandem compound condensing machines of 200 H.P., which can be raised to 260 H.P. in an emergency, and run at 96 revolutions per minute. The low-pressure alternators are coupled directly to the engines, and have rotating field-magnets inside a stationary armature, and are 80-volt three-phase machines. Two 30-kilowatt direct-current machines are driven by belts from the fly-wheels of the engines, and serve not only for producing the energy required for lighting and for small motors, but also for exciting the alternators and for charging accumulators in the day-time.

The alternate currents are transformed up to 660 volts at the station, and distributed by means of a cable network to motors, and to three-phase dynamotors, producing direct currents, which feed into the direct-current cable system, and are aided by the above-mentioned direct-current dynamos. The object of this arrangement is, by the multiplication of transformers, and therefore of feeding points, to reduce the drop in the mains, and thus

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save copper. The current is supplied to four distributing centres direct from the station, and the remainder are fed from the transformer sub-station. The transformer is simply a three-phase motor with an extra winding, commutator, &c., giving direct currents. The three-phase network is calculated to supply an aggregate of about 300 H.P. for motors, and the direct current system to take 4,000 lamps (8 c p.).

It is interesting to note that before the station was made the total expenditure of energy in motive power in Bockenheim was about 400 H.P., and of this, after less than a year, 160 H.P. are on the electric mains, and applications have been received for 50 H.P. more.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

The 1893 Edition of "THE ELECTRICIAN" Electrical Trades' Directory and Handbook is NOW READY. This useful book contains over 1,000 pages, and several new and handy features have been added. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

TENDERS INVITED.—The Guardians of the Woodstock Union invite tenders for supplying and fixing electric bells in the workhouse. Tenders must be in by to-morrow (Saturday).

TENDER ACCEPTED.—The St. Pancras Vestry have accepted the tender of Messrs. Johnson and Phillips for their "D. P." accumulators for the extension of the Regent's Park central station.

SALES BY AUCTION.—Messrs. Wheatley Kirk, Price and Goulty announce in our advertisement columns that their sale by auction of the contents of the works and show-rooms of Messrs. Fawkner, Rogers and Co., at 11 and 12, New Bridge-street, London, E.C., will take place on Thursday next, the 7th inst. The sale will include steam and gas engines, three new dynamos, lathes, planing, drilling, and screwing machines, shafting, fans, &c.; and the lots may be viewed on Wednesday and on the morning of the sale. Catalogues may be obtained from the auctioneers, 49, Queen Victoria-street, E.C.; from the receiver, Mr. H. Jackson, 53, Coleman-street, E.C.; and from Mr. T. G. Vickery, Church Court-chambers, Old Jewry, E.C.

——— Messrs. Wheatley Kirk, Price and Goulty also announce that the sale of the plant, &c., of the Northern Telegraph Works, Halifax, will take place on September 12th, 13th, 14th, and 15th, instead of as previously announced. The advertisement in another column gives some particulars of the plant, machinery, fittings, patterns and drawings, patent rights, &c., to be included in the sale; and catalogues are to be obtained from the Auctioneers, 49, Queen Victoria-street, London, E.C., and Albert-square, Manchester; and from Messrs. Lakeman and Olliver, 44, Prudential-buildings, Park-row, Leeds.

TELEPHONE INSTRUMENTS AND STORES FOR SALE.—The National Telephone Company invite tenders for a large quantity of old instruments and stores, particulars of which can be obtained of the Stores Department, Oxford-court, Cannon-street, E.C.

EXHIBITION.—A Universal Exhibition is to be held in Madrid from April to October, 1894. A circular has been issued inviting English manufacturers to participate.

PRESENTATION.—Mr. Vincent Swindells, who was connected with the Mutual Telephone Company from its foundation, and later with the New Telephone Company at Manchester, has been presented by his colleagues with a handsome testimonial, upon his leaving to assume the representation in the North of England of the Fowler-Waring Cables Company (Limited).

FAILURE.—Before the Leeds Official Receiver in Bankruptcy, on Thursday last week, a meeting was held of the creditors of Harry Austin and James Myers, trading as Austin and Myers, manufacturing electricians and electrical engineers, Armley. The joint liabilities were stated to be £261. 18s. 11d., and assets £79. 4s. 6d. The debtors attributed their difficulties to cost of advertising and bad debts. No resolution was passed.

LIQUIDATIONS.—The Société Française d'Accumulateurs électriques Faure-Sellon-Volckmar is to be voluntarily wound up.

LIQUIDATIONS.—The first meeting of creditors of the International Electric Syndicate (Limited), which was ordered to be wound up in November last, will be held at 33, Carey-street, Lincoln's Inn, W.C., on September 7th, at 11 a.m.

——— Mr. Stuart Lowden, accountant, of Pontefract, has been appointed liquidator of Mountain's Wire Manufacturing Company (Limited) (in liquidation).

MESSRS. RUSSELL AND CO.—This firm inform us that they have taken over the contracting business hitherto carried on by Mr. Medhurst at Cambridge, and have work in progress at several of the colleges. Their local office is 6, St. Andrew's-street, Cambridge.

MESSRS. J. H. HOLMES AND CO.—This firm have obtained the contract to light by electricity the newly-erected premises of the Prudential Assurance Society at Newcastle-on-Tyne.

ELECTRIC PUMPING PLANT.—We learn that the Corlett Electrical Engineering Company (Limited) have secured a contract for supplying and erecting a large pumping plant for the Consett Iron Company (Limited). It will consist of a three-throw ram pump driven by an electric motor, and two centrifugal pumps, each coupled direct to an electric motor. The current for all three motors will be supplied from a dynamo to be placed in an engine-house on the surface and situated about a mile and a-half from the pumps.

MINING MACHINERY.—The Jeffrey Manufacturing Company are introducing their machines to the colliery proprietors of Great Britain. Their machines include one for undercutting coal, which the Company claims takes a cut of 3ft. wide and up to 6ft. deep in about 20 minutes; and a drill which is stated to bore a hole for blasting 2in. diameter by 6ft. deep in about two minutes. The English business will be worked by Messrs. John Davis and Son, who have undertaken the management for the United Kingdom. Electric motive power is usually employed, and the machines for safety lamp pits will be fitted with the Davis and Stokes safety motor.

THE LEEDS AND LONDON ELECTRIC ENGINEERING COMPANY.—This Company, with which Mr. Robert Hammond is intimately associated, have sent us a well-illustrated catalogue of Lowrie-Hall transformers, fuses, switches, and fault-detectors, and surface and junction boxes, as used by the various supply companies with which Mr. Hammond is connected. The appliances, all of which are under Lowrie-Hall patents, are of substantial design, and apparently well suited for their work.

MESSRS. R. CRITTALL AND CO.'S CATALOGUE.—Messrs. Crittall and Co. have sent us a catalogue of door furniture, electric light switch covers, and panels for switches and cut-outs. The work is for the most part low relief chased *repoussée*, and is produced by electrotyping from original models. The artistic design excels anything that we have seen for a long time, and is altogether on a different level from the gaudy and ostentatious styles to which we have so often objected. Switches are as a rule only one degree less hideous excrescences in a well-decorated room than cut-outs. The latter are fortunately relegated for the most part to distributing boards, but Messrs. Crittall and Co. illustrate some beautiful panels with sets of switches and cut-outs. Electric bell pushes are treated in the same style.

MESSRS. COLE, MARCHANT AND MORLEY.—This firm have sent us a catalogue of steam engines, and call attention to their automatic positive Corliss engine, with Morley's patent gear, which they recommend for electrical work.

ELEKTRICITÄTS-GESELLSCHAFT HAMBURG.—We have received from this Company a price-list of their "Venus" and "Bifilar" incandescent lamps, together with an intimation that the increasing sale of these lamps has rendered necessary an enlargement of their works.

ELECTRICITY *v.* GAS.—The annual report of the North-Eastern Sanitary Inspection Association, just issued, states, with regard to the electric light, that "not only is it purer, and consequently healthier, than gas, but that, light for light, it is only a little dearer than the older illuminant."

BARTON.—The Workhouse Extension Committee are preparing a report for the Board of Guardians on the subject of the relative cost of the electric light and gas.

BRISTOL.—The local Gas Company held its half-yearly meeting last week, and Mr. Alderman J. W. S. Dix, who presided, said he thought the power which Corporations had of carrying on electric lighting works at the cost of the ratepayers was unfair to the gas companies, who were in most cases probably the largest ratepayers.

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He looked forward without concern to the competition which the Bristol Gas Company would shortly have with the electric light. The maximum dividend was declared.——The Industrial and Fine Arts Exhibition, opened on Monday, is lighted by electricity generated at the Corporation's new central station. In the building are 20 arc lamps of 1,000 c.p. each, and between 300 and 400 incandescent lamps, mainly of 16 c.p. The industrial section is illuminated by 18 arc lamps, arranged in two series on circuits of 105 volts, and underneath the galleries, and elsewhere where necessary, are incandescent lamps. The arts section is lighted entirely with incandescent lamps, electroliers of numerous designs being brought into requisition. The electric current from the Corporation works is conveyed to a station within the building, which is an exact model of the numerous sub-stations in different parts of the city which the Corporation will own. From this chamber the whole of the lamps in the Exhibition will be controlled. The search-light in one of the towers is to be ready shortly. All the arrangements for the illumination have been carried out by the Electric Lighting Committee of the Exhibition, under the direction of Mr. H. Faraday Proctor, the resident electrical engineer to the Bristol Corporation, who is a member of that Committee.

CANTERBURY.—The Brush Company have intimated their acceptance of the agreement for the transfer of the Electric Lighting Provisional Order for Canterbury, and the installation will now be proceeded with.

EDINBURGH.—The Lord Provost will turn on the electric light at the Powderhall Refuse Works between 7 and 9 o'clock on the evening of September 11th.

FALMOUTH.—An exhibition is to be held in the Polytechnic Hall, which is to be lighted by electricity for the occasion. Messrs. Veale have received instructions from Mr. J. Grose (ex-Mayor) to instal the electric light in his new premises, which include several large shops.

FORT WILLIAM (CALCUTTA).—The proposal to light Fort William by electricity, which has been under consideration for some years, has been negatived owing to want of funds.

KIDDERMINSTER.—A few weeks ago circulars were sent out to the inhabitants by the Improvement Committee of the Town Council with the idea of ascertaining the probable demand for the electric light if the Corporation should decide to take up the matter, and at a recent meeting of the Council the Mayor said that the majority of the replies had been received, and a report was being prepared.

RICHMOND.—The construction of the electric light buildings at Richmond has been temporarily delayed by the going out on strike of 50 men, who have, however, now returned to work.

TAUNTON.—The electric Lighting Committee of the Town Council recommend that the purchase of the electric lighting works should be completed by September 30th, that Dr. J. A. Fleming, F.R.S., be appointed consulting engineer for one year, and that the services of Mr. H. E. Hunt as electrical engineer be retained at a salary of £150 per annum. The recommendations have been adopted.

TOTNES.—An attempt to introduce electric bells for summoning the members of the Fire Brigade on an outbreak of fire has lamentably failed, to the great satisfaction of some members of the Town Council, who consider that as "the church bells have sufficed for hundreds of years the practice of ringing them in case of fire should be continued." The introduction of the electric bells would have entailed a capital outlay of £13. 7s. 6d., and an annual charge of £1 for repairs.

WINDSOR.—Messrs. Roger Dawson (Limited) have agreed to rent the works and plant of the Windsor and Eton Electric Lighting Company (Limited) for the purpose of supplying the existing customers and to prevent the deterioration of the plant; and the current is now being supplied by the first-named Company. Efforts are being made to induce the Corporation to take into their own hands the question of the electric light.

BOOKS RECEIVED.

"Griffin's Electrical Price Book." By H. J. Dowsing. (London: Charles Griffin and Co.)

"Institute of Chemistry of Great Britain and Ireland." Regulations for admission to membership and register. Issued by Council, April, 1893.

"Journal of the Institution of Electrical Engineers." (London: E. and F. N. Spon.)

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

August 5, 1893.

15,050. H. OPPENHEIMER. London. Slow striking electric bells.

15,064. F. W. and S. J. SUTER. London. An improved electric arc lamp.

15,073. H. H. COOPER and THE ELECTRICAL INSTALLATION COMPANY (LIMITED). London. Improvements in electric arc lamps.

15,074. H. H. COOPER and the ELECTRICAL INSTALLATION COMPANY (LIMITED). London. An improved electric coupling.

August 8, 1893.

15,110. F. A. PERRET. Manchester. Improvements in apparatus and devices for starting, stopping, and reversing electromotors.*

15,151. F. S. PALMER. London. Improvements in circuit-testing apparatus.*

15,156. P. RABBIDGE. London. Improvements relating to telephones.

August 9, 1893.

15,198. L. B. MILLER and M. W. WOODS. London. Improvements in apparatus for obtaining ignition by means of electricity.

15,217. G. C. DYMOND. Liverpool. Improvements in electric cables.

15,231. A. J. BOULT. London. Improvements in electric arc lamps. (A. Bureau, Belgium.)

August 10, 1893.

15,248. E. A. CLAREMONT. Manchester. Improvements in joints for electric light, gas, water, and other similar fittings.

15,257. S. MARCUS. London. Improvements in and connected with galvanic batteries.*

15,264. P. MARINO. London. Improvements in plating metallic surfaces and also prepared surfaces of non-conducting substances by electrochemical deposition.*

August 11, 1893.

15,284. D. F. ADAMSON. London. An improved safety device for facilitating the replacing or removing of electric fuses.

15,322. A. T. COLLIER. St. Albans. Improvements in instruments for telephonic and telegraphic transmission of speech or sounds.

15,337. E. D. TRESEL. London. Improvements relating to electric arc lamps.

15,339. L. BOURGEOIS. London. Improvements in cases for electric bell mechanism.

15,343. W. OSENBERG. London. Improvements in and relating to the attachment of electric lamps to their posts.*

August 12, 1893.

15,355. H. S. PYNE and R. THOMPSON. Chester. An improved electric battery.

15,373. F. W. DAVENPORT, U.S. America. Electric light fixtures. [Date applied for under Patents, &c., Act, 1883, Sec. 103, January 16, 1893, being date of application in United States.]*

15,396. F. HURTER. London. Improvements in or connected with apparatus for the manufacture of chlorate of potash by electrolysis.

15,406. W. H. AKESTER and THE AKESTER ELECTRIC SYNDICATE (LIMITED). London. A new or improved "cut-out" to be employed in connection with electric arc lamps.

August 14, 1893.

15,409. B. G. SMITH. Halifax. Improvements in electric switches.

August 15, 1893.

15,476. L. FALERO. London. Improvements in primary voltaic batteries.

15,479. L. E. HOWARD. London. Improvements in electric arc lamps.*

15,485. E. MANN and J. HOPWOOD. London. Improvements in glow lamps and holders.

15,486. E. MANN and J. HOPWOOD. London. An automatic switch for electric and other light, applicable to a door.

15,510. J. BROCKIE. London. Improvements in electric arc lamps.

15,519. R. W. BARKER. London. Improvements in electric engines. (The Lawrence Electric Company, United States.)*

15,523. W. MCNEILL, J. H. TINDER, and S. P. KERR. London. Improvements in recording meters for electric light and power circuits.

August 16, 1893.

15,577. F. CHAPLET. London. Improvements in electric furnaces.

August 17, 1893.

15,610. F. G. BAILY and M. GUTHRIE. London. Improvements in apparatus for the electrolytical decomposition of brine and other liquids.

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15,617. F. G. Baily and M. Guthrie. London. Improvements in apparatus for the electrolytical decomposition of brine and other liquids.

August 18, 1893.

15,663. F. C. Lynde. Manchester. Improvements in the covers and frames of manholes used for drainage work, electric light, and other purposes.

15,669. N. Browne. London. Apparatus for the electroly tic treatment of liquids. (A. Vogelsang, Germany.)*

15,681. G. H. Roe and G. Sutro. London. Improvements in electric accumulators or storage batteries.*

15,690. D. Tweddle. London. Improvements in electric marine governors.

15,715. W. G. and C. W. G. Little. London. Improvements in or connected with means for the supply or distribution of electricity.

August 19, 1893.

15,736. G. and T. Edward. Glasgow. Improvements in and relating to machinery for covering telegraph, telephone, and electric cables, and wires with lead or metallic compounds also applicable for the manufacture of metallic pipes and the like.

15,776. J. L. Huber. London. An improved electric apparatus termed "gubernograph" for use on ships to indicate and register the position of the rudder and the reversing gear of the engine.

August 21, 1893.

15,781. T. P. Rennoldson. Banbridge. An improved system of electric wiring.

15,784. J. C. Simmonds. Chichester. An improvement in electropathic body belts.

15,789. J. P. Gorton. Weston-super-Mare. An automatic method of starting and stopping the paper of Morse telegraph and other recording instruments.

August 22, 1893.

15,806. D. Young. London. Improvements in and relating to electrolytic apparatus. (La Société Outhenin Chalandre Fils et Cie., France.)*

August 23, 1893.

15,907. H. Koster. London. Improved insulator for telegraph and telephone wires.

15,933. A Spark. Aberdeen. Improvement in telephones.

15,957. La Société Anonyme pour la Transmission de la Force par l'Electricité. Liverpool. Improvements connected with assistant or auxiliary electromotors. [Date applied for under Patents, &c., Act, 1883, Sec. 103, March 15, 1893, being date of application in France.]*

15,963. B. Zeitschel. London. Improvements in electric indicators.*

August 24, 1893.

15,971. G. L. Anders and W. Köttgen. London. Electro-magneto motor for maintaining uniform speed.

15,974. J. J. Green and W. Oates. Halifax. A new form or construction of tube or pipe for carrying or supporting electric wires underground.

15,997. T. Malson, S. R. Malson, W. A. Malson, and E. Smith. London. Improved electric high-tension fuse head, for use in blasting.*

16,000. C. A. Allison. London. Improvements in telegraphy. (P. J. Wicks, United States.)*

16,008. A. Piedfort. London. Improvements in, or relating to, multiple telegraphy.*

16,017. H. W. and G. J. Gibbs. London. Improvements in electrically-actuated machine tools.

16,019. O. André. London. Improvements in metal posts or supports for electric wires or cables, also applicable for other purposes.

16,025. Siemens Bros. and Co. (Limited). London. Automatic coupling for electromotors. (Siemens and Halske, Germany.)

16,026. Siemens Bros. and Co. (Limited) and E. Holmes. London. An automatic regulator for dynamo-electric machines.

16,027. Siemens Bros. and Co. (Limited) and H. G. Knorr. London. Improvements in connections for local supply from electrical mains.*

16,028. Siemens Bros. and Co. (Limited). London. A method of compensating variations of load at electrical stations. (Siemens and Halske, Germany.)

August 25, 1893.

16,060. G. T. Pardoe and G. Broughall. Manchester. Improvements in electric arc lamps.

16,074. A. Geyer and J. Stegmeier. London. Improvements in apparatus for lighting gas by electricity.*

August 26, 1893.

16,133. W. P. Thompson. Liverpool. Improvements in electrical devices for opening doors. (H. Schütze, Germany.)*

16,136. A. J. Boult. London. Improvements in or relating to electrodes for primary and secondary batteries. (R. T. E. Hensel, Germany.)*

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

14,658. Smith. Secondary batteries.
17,643. Edmunds. Electric switches.
17,922. King and Clark. Secondary batteries.
24,127. King. Secondary batteries.

1893.

2,161. Miller and Woods. Heating liquids by electricity.
6,907. Best. Chandeliers and electroliers.
9,039. Denison. Autographic telegraph apparatus.
9,819. Hall. Electric circuit controlling devices.
11,464. Thompson (Biermanns). Galvano electric belt.
11,819. Allen. Electric railway trollys.
12,374. Gover. Electric lamps.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "The Electrician" Electrical Trades' Directory and Handbook, 1893, pages 320-348, *&c., &c.*]

AMERICAN INSULATED WIRE COMPANY (LIMITED).—In consequence of the non-completion of the arrangements for the purchase of an insulated wire manufacturing business in America this Company desires erasure from the register, as no business of any kind has been done.

T. S. McINNES AND CO. (LIMITED).—This Company was registered last week, with a capital of £3,000, in 1,000 Preference and 2,000 Ordinary shares of £1 each. The objects are to carry on the business of electrical and scientific instrument makers, &c., in continuation or extension of the business at present carried on by the firm of T. S. McInnes and Co., Glasgow.

ARC ACCUMULATOR COMPANY (LIMITED).—The recently-filed returns of this Company for 1892 and 1893 show that only the seven signatories' shares have been allotted, no payments having been requested.

ATLAS CARBON MANUFACTURING COMPANY (LIMITED).—The annual return of this Company, made up to June 11th, has been filed, and shows that the whole nominal capital of £2,000, in shares of £1 each, have been allotted as fully paid.

BOARDMAN'S ELECTRIC SUN LAMP PATENTS (LIMITED).—The statutory return of this Company, made up to July 18, 1892, was recently filed, when seven shares out of a capital of £10,000, in £5 shares, were taken up, and the full amounts called and paid on them.

BRITISH ELECTRIC TRAMWAYS AND GENERAL SYNDICATE (LIMITED). The annual return of this Company, made up to July 28th, has been filed. The Company has a nominal capital of £10,000, divided into 1,850 "A" and 150 Founders' shares of £5 each. 7 "A" and 87 Founders' have been taken up. No calls have been made on the former, while the full amount has been called and £435 paid on the latter class of shares.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended August 27th were £716, as against £805 for the corresponding period of last year, being a decrease of £89. The total receipts for the half-year amount to £6,628, against £6,190 in the corresponding period of 1892, being an increase of £438.

DIRECT CABLE COMMUNICATION WITH SPAIN.—The Direct Spanish Telegraph Company's Falmouth-Bilbao cable has been repaired, and direct cable communication by Spain with that route is now restored.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announces the connection, by submarine telegraph cable, of the Islands of the Azores with Lisbon and the general system of cables. Telegrams are accepted for delivery in the Islands at the tariff of 10d. per word, and should be handed in at postal telegraph stations marked "*Vid* Eastern."

STOCK EXCHANGE NOTICES.—Applications have been made to the Stock Exchange Committee to allow the following securities to be quoted in the Official List: Brush Electrical Engineering Company, further issue of 15,000 Preference shares and 10,000 Ordinary shares; Commercial Cable Company, further issue of $2,284,000 capital stock; Electric Construction Company, Ordinary shares in lieu of those of the old Corporation.——The Committee appointed Tuesday last, the 29th ult., a special settling day in the £200,000 (part of £300,000) Four per Cent. Registered Mortgage Debentures, Nos. 1 to 8,000, of the Eastern and South African Telegraph Company (Limited) (Mauritius Subsidy); and they have ordered these securities, and the further issue of 25,730 Ordinary

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shares Nos. 458,868 to 484,597 28,284 Five per Cent. Non-Cumulative Third Preference shares, Nos. 90,951 to 119,234, and £198,540 (part of £273,523) Four and a-Half per Cent. Debenture stock of the National Telephone Company (Limited), to be quoted in the Official List.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended August 25, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,810.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Aug. 23.	Price Wednesday, Aug. 30.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 30. Highest	Lowest.
			TELEGRAPHS			£ s. d.			
£1,134,640	Stock	12/6	Anglo-American	49 50	49½ 50½	5 8 11	Jan. Apr., July, Oct	49	48½
£2,932,680	Stock	25/0	Do. Preferred	92 93	92 93	5 18 3	" "	92⅞	92⅜
£2,932,680	Stock	5/0	Do. Deferred	9 9½	9½ 10	..	.. ..	9⅝	..
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	99 102	99 102	3 18 5	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11¾ 12¼	11¾ 12¼	5 6 1	Mar., June, Oct., Dec	11⅞	11⅞
£36,400	£100	5%	Do. 5 per Cent. Bonds	99 103	99 103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107 111	107 111	4 10 1	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	120 130	120 130	5 7 8	April and October	..	..
16,000	10	8/0	Cuba Submarine	11½ 12¾	11½ 12¾	6 8 0	February and August	12⅝	11⅞
6,000	10	10%	Do. Preference 10 per Cent.	18½ 19½	18½ 19½	5 2 7	" "	..	..
14,931	5	1/7½	Direct Spanish (£4 paid)	2½ 3½	2½ 3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	8½ 9½	8½ 9½	5 5 3	" "	..	..
60,710	20	3/6	Direct United States xd	11½ 11¾	11⅝ 11⅞	6 0 2	Jan., Apr., July, Oct	11⅝	11½
400,000	10	5/6	Eastern	14½ 15	14⅝ 15⅛	4 5 11	" "	15⅛	14½
70,000	10	6%	Do. 6 per Cent. Preference	16½ 16¾	16 16⅜	3 12 9	" "	16⅛	16⅛
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112 115	111 114	3 10 2	May and November	114	111
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	105 109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15 15½	15 15½	4 11 10	Jan., Apr., July, Oct.	15⅛	15⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	110 113	110 113	3 10 10	February & August	111½	110
£70 600	100	5%	Do. 5 p. c.(Austln. Gov. Sub.) Debs 1900	102 105	102 105	4 15 3	January and July	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	100 103	100 103	4 17 1	" "	102½	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	100 103	100 103	3 17 8	February & August	..	..
£200,000	£25	..	Do. 4% Mauritius Sub. Debs.	103½ 104	102 105	..	May and November	103⅜	..
180,227	10	4/0	Globe Telegraph and Trust	9⅜ 9⅞	9⅜ 9⅞	4 13 8	Jan., Apr., July, Oct.	9⅝	9⅜
180,042	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 18 8	" "	15½	15
150,000	10	5/0	Great Northern	19½ 20	19¾ 20⅛	4 4 2	Jan., April, and July	19⅝	19⅜
£200,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105 108	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	39 42	39 42	5 19 1	May and November	..	..
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	3 6 8	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs.	106 103	100 103	3 17 8	.. ..	..	..
11,802	8	4/0	Reuter's	4½ 5½	4½ 5½	..	April and October	..	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6 per Cent.	115 120	115 120	5 0 0	" "	..	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July	..	..
£260,900	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	2 3	2 3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	97 101	97 101	7 18 5	June and December	..	..
88,321	10	6d.	West India and Panama	1 1½	1 1½	..	..	1 1/16	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 10¾	10½ 10¾	5 11 7	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	105 108	105 108	4 12 7	June and December	..	..
64,242	15	4/6	Western and Brazilian	6½ 6¾	6½ 6¾	5 15 7	May and November	6⅝	..
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5¾ 6¼	5¾ 6¼	..	..	5⅝	5 11/16
33,129	7½	4/6	Do. 5 per Cent. Deferred	1½ 1¾	1½ 1¾	..	..	..	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	..	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120 125	120 125	5 12 0	May and November	..	..
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	101 104	101 104	5 15 5	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	2 3	2 3	..	..	..	..
224,850	10/0	3½d.	Consolidated Telephone Const. & Maintenance	1/16 3/16	1/16 3/16	..	May and November	1/8	..
220,000	£1	4½d.	Oriental (11s. paid)	3/16 5/16	3/16 5/16	7 18 2	Yearly	..	..
458,867	5	2/6	National	4⅜ 4½	4⅜ 4½	5 8 1	June and December	4 1/16	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14½ 15½	14½ 15½	3 17 5	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14 15	14 15	4 0 0	" "	14⅜	14¼
90,950	5	2/0	Do. 5% Non-Cumulative 3rd Pref.	5½ 5¾	5½ 5¾	4 10 11	..	5 1/16	5⅛
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	111 113	111 113	3 19 8	January and July	112½	111½
58,000	5	1/0	United River Plate	2 2½	2 2½	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	11 11½	11 11½	..	..	..	..
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½ 13	12½ 13	..	..	13	12½
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	.. ..	.. ..	..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
8,322	£5	..	House to House Electric	.. ..	.. ..	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	.. ..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4 3/16 4 5/16	4 3/16 4 5/16	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6⅜ 6⅝	6⅜ 6⅝	..	..	..	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	5½ 6¼	5½ 6¼	3 4 0	..	6⅜	5⅝
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102 105	102 105	4 15 3	June and December	..	..
6,452	£10	..	Notting Hill Electric	5 6	5 6	..	..	..	..
19,980	£5	9½%	St. James' and Pall Mall	6½ 6¾	6½ 6¾	..	..	6⅞	..
20,000	£5	7%	Do. 7 per Cent. Preference	7¾ 8¼	7¾ 8¼	4 4 10	..	8¼	..
59,900	5	1/6	Westminster Electric Supply (fully paid)	5 5½	5 5½	3 3 8	..	5⅝	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/6	Brush Electrical Engineering	3 3¼	3 3¼	..	..	..	..
75,000	2	6%	Do. 6 per Cent. Preference	2 2¼	2 2¼	5 6 8	..	2¼	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107 109	107 109	4 2 7	March & September	..	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref xd	4½ 5	4 5	7 0 0	January and July	..	..
12,139	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	.. ..	..	..	..	..
49,900	10	12/0	Electric Construction	1½ 1⅝	1½ 1⅝	..	..	1⅝	1½
91,195	2	10/0	Elmore's Patent Copper Depositing	¼ ⅜	¼ ⅜	..	..	3/16	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22½	22
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	1½ 2½	1½ 2½	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/0 4/0	3/0 4/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	2 2½	1⅜ 2⅛	15 11 3	May and November	2 3/16	..
37,350	12	12/0	Telegraph Construction and Maintenance	33 35	32 34	5 5 10	March and July	34⅜	34
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	January and July	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	¾%	City and South London Railway xd	35 37	35 37	1 13 9	May and November	36¾	..
37,500	£10	..	Liverpool Overhead Railway	5½ 5½	5½ 5½	..	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 799.—Vol. XXXI. FRIDAY, SEPTEMBER 8, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

Among the electrical Papers which have been promised for Section A of the British Association are two by Lord Kelvin, "On the Piezo Electric Property of Quartz" and "On a Piezo Electric Pile." Mr. E. H. Barton will read a Paper on "Electrical Interference Phenomena, somewhat analogous to Newton's Rings, but exhibited by Waves in Wires," and the other Papers will be "The Passage of Electric Waves through Layers of Electrolyte," by G. H. Yule; "On Standards of Low Electrical Resistance," by Prof. J. Viriamu Jones; "The Specific Resistance of Sea Water," by W. H. Preece; and "An Alternating-Current Potentiometer," by James Swinburne. Among the reports will be "Electrical Standards" and "Magnetic Work at Falmouth Observatory."

The principle of sacrificing efficiency in order to prolong life or reduce depreciation is one which is applied in more than one industrial process or invention. The Paper read by Mr. L. B. Marks at the International Electrical Congress, at Chicago, which will be found in another column, is a further illustration of this principle, as applied to electric lighting. By enclosing the electric arc in a confined space, thereby depriving it of free oxygen, and allowing the development of a pressure considerably greater than that of the atmosphere, Mr. Marks has succeeded in maintaining the arc with a very reduced consumption of carbon, but requiring an amount of power per candle considerably above the normal. The precise point at which such a practice ceases to be economical will, of course, depend upon the relative cost of energy and of carbon, as well as on the cost of labour in trimming; and it must not be forgotten, in estimating the commercial value of the incandescent arc invented by Mr. Marks, that in this country the consumption of arc-lamp carbon for a given amount of light has been reduced, by other and more simple means, to a value far below that which is now common in America.

The phenomenon of a cylinder full of soft refulgent light, which it is claimed that this lamp produces instead of the sharp local arc, is one which, if it could be obtained with unimpaired efficiency would, serve a better purpose than the usual arc. But it must not be forgotten that such a phenomenon, where large candle-power is concerned, is impossible in a purely gaseous and transparent atmosphere; and that, on the contrary, the very existence of this translucence of the enclosed atmosphere implies the existence of smoky vapour or finely-divided particles of carbon in the enclosed space around the arc. This, together with the inevitable incrustation of solid carbon on the surrounding glass cylinder, must greatly tend to reduce the efficiency, and to increase the cost of cleaning, the lamp.

A striking series of experiments on contrast colours is described in the August number of the *Phil. Mag.* by Prof. Alfred M. Mayer; and considerable interest attaches to them owing to the bearing they have on photometry. The difficulty arising in judging the relative candle-power of two lights which differ in colour is well known. It is often got over by the use of red and green glasses. But the objection to this method is that it gives two results, neither of which is the one wanted, and which cannot be combined together to yield the value required. The true illuminating power can only be estimated by judging the intensity of the two parts of the photometer disc in spite of colour differences; and after a little practice this can be done with a degree of accuracy quite sufficient for most purposes. The colour difference between the lights which are being compared always appears greater than it really is, owing to a peculiar optical effect, the reason for which is not yet satisfactorily settled. It is well known that dark spots on a coloured background appear coloured, the hue being complementary to that of the background. Thus black spots on a red ground appear green, while if the ground is green, they seem red. This effect has to be taken into consideration by artists, and it occurs with a Bunsen, or other similar, photometer when the lights compared are of different colours, the two parts of the screen appearing, by contrast, in complimentary hues.

It is this contrast effect that Prof. Alfred Mayer has set himself to investigate, and the experiments he describes are both simple and convincing. Among other results he proves that the perception of these effects is instantaneous. The ignorance hitherto enveloping this subject is shown by the fact that the contrast colour observed has always been attributed to an "error of judgment" on the part of the eye. As, however, the effect takes place when the colours are only seen by the instantaneous flash of an electric spark, it is no longer possible to hold this theory, unless it is assumed that the mental operations necessary for this judgment can occur in less than one-millionth of a

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second. Probably what is necessary to see these effects is not so much a minimum interval of time as a minimum amount of light. The electric spark, although only "momentary," gives out an appreciable quantity of light. Incidentally also these experiments give evidence in favour of HERING's theory of colour, as opposed to the usually accepted theory of YOUNG and HELMHOLTZ, and it is therefore specially appropriate that, in a later part of the same number of the *Phil. Mag.*, Dr. WILLIAM POLE gives an abstract of Prof. HERING's little known theory of colour, in connection with the explanation of colour blindness. Prof. ALFRED MAYER's Paper concludes with the description of a new photometer, specially designed for the measurement of coloured lights. This is an ingenious instrument, by means of which the quality of the colour of any light tested can be accurately measured. It is not suitable for commercial work, although of great scientific interest.

THE determination of the solubility of salts so sparingly soluble that they are generally ranked as typically insoluble substances, is no easy matter. The evaporation of a known quantity of a saturated solvent and the weighing of the residue constitute a tedious and inexact process when a litre or more of liquid has to be got rid of, and a milligram or less of the dissolved solid remains to be weighed. An attempt has recently been made by HOLLEMAN to compute the solubility of such substances—of which barium sulphate will serve as an example—from the determination of the electrical conductivity of their solutions. According to modern views, solutions when of great tenuity contain the ions of the dissolved salts in a state of dissociation, and even saturated solutions of bodies which are, in ordinary parlance, insoluble, are sufficiently dilute to fulfil this condition. The electrical conductivity of a solution of a dissociated salt is proportional to the number of ions, and hence to the quantity of the salt, present. These principles can obviously be applied to the determination of the solubility of every salt in dilute solution.

SOME of the values obtained in this manner are of considerable interest. Thus barium sulphate is soluble in 429,700 parts of water at 18·9°C., and in 320,000 parts at 37·7°C., the effect of temperature being therefore considerable. On the other hand, the analogous salt strontium sulphate is soluble in rather more than 10,000 parts of water alike at 16°C. and 26°C. The amount of water required for the solution of silver chloride at 13·8°C. is 715,800 parts, and falls to nearly half its value at 26·5°C., being then only 384,100. As might have been supposed, the most nearly insoluble salt hitherto examined is silver bromide, which needs no less than 1,971,650 parts of water for its solution at 20·2°C., while the next is silver bromide requiring 1,074,040 parts at 28·4°C. It would be instructive to compare the figures for these three halogen salts of silver at the same temperature and ascertain what relation exists between them. Such a comparison is possible with the carbonates of barium, strontium, and calcium, as their solubilities have been determined at 8·8°C., giving the values 64,070, 121,760, and 99,500. Unfortunately, however, if this group of metals be regarded, strontium must be looked upon as the middle member, so that the fact that an extreme value has been obtained for the solubility of its carbonate makes confirmation of the precision of the determination requisite before an explanation can be profitably sought.

THE fussy and wearisome cross-questioning to which the POSTMASTER-GENERAL continues to be subjected in regard to the agreement with the National Telephone Company no doubt serves to bring the questioners into undue Parliamentary prominence, but the opportunity of rendering any real public service occurred more than three years ago, and was allowed to slip. By the terms of the telephone licences the POSTMASTER-GENERAL is empowered to exercise his option of purchase at certain stated intervals. It was in June, 1890, that the first opportunity arose, and it is not until June, 1897, that the next will occur. No doubt Government purchase could take place in the intervening period, though upon comparatively onerous conditions. Such being the case it would surely have been better for Parliament and the Post Office to have employed the seven years of reflection they had given themselves in definitely deciding what they meant to do in this matter of telephonic communication, rather than in snarling and nibbling. In April, 1892—that is to say, exactly two years too late—Dr. CAMERON moved the purchase of the telephones, and was defeated by a large majority. A few weeks later we were, nevertheless, treated to a Treasury minute and a Telegraph Act, which committed the country to the half-hearted policy of trunk-wire purchase. And now, having by indecision placed the public interest at a disadvantage, our legislators are trying in futile fashion to get out of the muddle by badgering the POSTMASTER-GENERAL. The Post Office may be trusted to make as good a bargain as the circumstances of the case permit, and if the public is not altogether satisfied with the result it will at least know who is to blame.

"ALTHOUGH we may never know what electricity really is," says a New York contemporary, "any more than we now know what is life or the force of gravity, might we not at the present Electrical Congress plant a milestone in the progress of science by stating what we, at the present time think it is?" Our contemporary ventures to suggest that an electric circuit may be "an exaggerated atom," since both an atom and an electric current have been explained on a vortex hypothesis. This is something to go on with—a kind of hole into which the milestone may be planted. The difficulty which is likely to arise, however, is that other people of as undoubted authority as the Chicago Congress will also "plant milestones" recording their thoughts about the nature of electricity, so that when MACAULAY's New Zealander reviews the past, he is likely to be confused by the conflicting records. The present state of our knowledge about the nature of electricity is too speculative, too imperfect, to justify anything of the nature of a manifesto, ukase, or "milestone" wherewith to pass it on to posterity.

THE American electrical journals which come to hand just as we go to press contain the report of the delegates of the

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International Electrical Congress at Chicago. The ohm, the ampere, the volt, the coulomb, the farad, the joule, the watt, and the henry have been adopted; and the Congress recommends the several Governments represented to formally adopt them as legal units of electrical measure. A committee appointed to consider the standard of light was unable to recommend the adoption either of the Von Hefner lamp or the pentane lamp. M. HOSPITALIER'S system of notation and symbols was not officially adopted.

Telephonic Communication between Norway and Sweden.—Telephonic communication between Stockholm and Christiania was opened on Saturday last week.

Cable Interruptions.—

	Dates of Interruptions.
Paramaribo—Ceara	August 9th.
Aden—Zanzibar	September 1st.

Salford.—The Local Government Board Inquiry, with reference to the proposal of the Salford Corporation to borrow £50,000 for electric lighting, will take place on the 19th inst.

Copper.—Statistics for the end of August show a decline of 1,100 tons on the stock as at the middle of the month, and a net advance of 10s. per ton. The deliveries considerably exceeded those of July.

Obituary.—The death is announced of Mr. Herbert Clifford Saunders, Q.C., at the age of 59. He took much interest in technical education, and had been Chairman of the Executive Committee of the City and Guilds of London Institute for several years.

Torquay.—The Town Council having considered a scheme of electric lighting submitted by a special committee, have decided to defer the matter for six months in view of the proposed consolidation of loans. The scheme was estimated to cost £18,000.

Electric Welding.—The Thomson-Houston Electric Welding Company, of Lynn (Mass.), has discharged all but eight of its *employés*, and the Company will not start again until general business conditions improve. The Company at one time employed 100 hands.

A Large Electric Candelabrum.—The new Parliament buildings in Berlin are to have, in the lobby, a candelabrum 26ft. 8in. in diameter, and carrying 12 arc lamps and 250 incandescents. It is to be decorated with statues of the legendary and historical characters of the Fatherland.

The Niagara Falls Scheme.—The *Electrical Engineer* of New York states that it is informed that on the recommendation of Prof. George Forbes the Cataract Construction Company have adopted Mr. Tesla's multiphase system as the sole method of distribution at Niagara Falls.

Whitehaven.—The municipal central station at Whitehaven was formally opened on Saturday last. The system of supply is the three-wire for domestic lighting and two-wire at 230 volts for public lamps, the lamps being run two in series. The plant capacity of the station is 165 kilowatts.

Railway Station Lighting.—The Great Northern Railway are going to electrically light Finsbury Park and King's Cross Stations. The electricity will be generated at the large works the Company have built at Finsbury Park.

The Sims-Edison Electrical Torpedo.—Preparations are nearly completed for important experiments by the United States Navy, at Newport, for launching the Sims-Edison electrical torpedo from a steamer at sea with a view to introducing it as a naval weapon. This torpedo was adopted three years ago by the United States engineers for coast defence.

Weston Instruments at the Chicago Exhibition.—Weston instruments have been adopted at the suggestion of Prof. Ayrton for all tests made by the Committee of Judges in the Department of Electricity. A laboratory with all the necessary apparatus has been fitted up in the north-west corner of the building, and an exhaustive series of tests will be made.

The Electric Light on May Island.—Last week the Lord Provost of Edinburgh and other members of the Board of Northern Lighthouses accompanied two German officers to May Island for an inspection of the electric appliances in the lighthouse. The visit was in connection with the proposal of the German Government to establish the electric light on Ruegen Island in the Baltic.

The Leeds Tramways.—Sir Douglas Galton, the arbitrator in the dispute between the Leeds Corporation and the Tramways Company, has sent his award regarding the purchase of the latter's undertaking. The effect of the award is practically to reduce the demand of the Company from £250,000 to £112,000 should the basis of valuation contended for by the Corporation be upheld by the High Court.

The Heilmann Electric Locomotive.—In a letter to the *Engineer* Mr. B. H. Thwaite states that he has received information that the Heilmann locomotive ran some trial trips last week. The smooth running was phenomenal; it "quite took the breath out of the railway engineers on the footboard; they could scarcely believe their eyes, their other senses failing to impress them that the engine was actually running."

The Repair of the Falmouth-Bilbao Cable.—The Directors of the Direct Spanish Telegraph Company, in appreciation of the promptitude with which the recent repairs to the Falmouth-Bilbao cable were effected, on Monday last presented Capt. Scott-Smith (captain of the c.s. "Electra") and Mr. Walter Murphy (chief electrician) each with a gold watch, suitably inscribed. The presentation was made by Mr. Ch. Gerhardi, manager of the Direct Spanish Company.

Manchester.—The annual abstract of the accounts of the several departments of the Manchester Corporation for the year ended March 31st last was issued last week. A new account appears this year in connection with the establishment of the electric light. Under the Order which the Corporation obtained in 1890, they were authorised to borrow £80,000 for electric lighting. Up to March 31st they had raised £50,200 of this sum. The total amount expended to March 31st was £41,720, the items being:—Land, £2,161; buildings, £9,337; machinery, £13,196; mains, £14,077; expenses prior to generating electricity, £2,906.

Portsmouth.—At the last meeting of the Town Council the following satisfactory resolution was carried after a brief discussion:—"That the account of the receipts and expenditure of the Electric Lighting Committee, both in respect of capital and income, be kept entirely distinct from all other accounts of the Corporation, so that the financial result of the working of the electric light scheme may be clearly seen; and that a statement showing such result be prepared every six months by the borough accountant, and submitted to the Council through the Finance Committee."

The Trolley Current and Telephone Cables.—Under this heading, Mr. J. Stanford Brown writes to the *Electrical Engineer* of New York, of August 23rd, as follows:—"A new form of trouble due to the grounded return current of the electric railway system in Brooklyn has developed within the last few days. Yesterday, a corps from the telephone company was engaged in removing a large cable from the conduit on Court-street, the lead covering of which had been eaten through by the current from the railway circuit. The foreman stated that this was the first cable from which they had had trouble from this cause. It is very much feared that all the other cables of that line will shortly have to be removed on account of this trouble."

Glasgow.—It is proposed to increase the salary of the Municipal Electrical Engineer to £350 per annum. The Secretary of State for Scotland has authorised the Corporation to borrow another £100,000 in connection with the electric lighting scheme, and on the strength of this sanction the proposed increase in plant has been commenced, the order for the steam engines having been left with Messrs. Siemens Brothers and Co. It is not expected that more than £6,000 will be spent on the proposed extensions. One hundred additional Ferranti meters have also been ordered, experience in Glasgow being very much in their favour.

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Engineering Courses.—Courses of lectures and laboratory instruction in electricity and other sciences applicable to the industrial arts will be given during the forthcoming winter session at the Royal College of Science, Dublin. Particulars will be found in our advertising columns, and it will be seen that this college offers considerable advantages in the shape of scholarships. Particulars also reach us of the courses of engineering instruction at University College, Liverpool, where a complete system of lectures and laboratory practice under Profs. Oliver Lodge and Hele-Shaw are provided for students in electrical engineering. The session at each of these colleges commences on October 2nd.

Quartz Fibres.—In a Paper recently read before the Franklin Institute, Mr. Northup (of Queen and Co, Philadelphia) states that quartz fibres can be obtained in a similar manner to glass fibres. Any wheel more than 3ft. in diameter and 4in. wide at the rim may be used. The circumference is covered with smooth black paper, across which a strip of fly-paper 1in. wide, with the sticky side up, is pasted. A quartz rod, $\frac{3}{16}$in. to $\frac{1}{4}$in. in diameter, is next prepared and fastened on to a brass rod. The quartz is then melted in the oxy-hydrogen flame, and another rod is then brought in contact with the fused end. By means of this second rod a thread is drawn over the wheel, which is rapidly revolved, and any length of fibre can then be drawn out.

The Municipal Corporations Association and the Telephone Question.—Arrangements have been made for an interview between a deputation from the Municipal Corporations Association and the Postmaster-General to take place after the recess. This interview is the outcome of the following resolution, passed some time since:—"That in the opinion of this Council no statutory powers should be conferred on telephonic undertakers unless statutory obligations and limitations are imposed on the undertakers, and that the Special Committee be requested to consider, as soon as possible, what these statutory obligations and limitations should be, and if they think it advisable to have an interview with the Board of Trade on the subject." The Special Committee interviewed Sir Courtenay Boyle last month, and were referred by him to the Post Office.

Registering Apparatus for Lightning Conductors.—Messrs. Siemens and Halske have lately introduced an apparatus designed for the purpose of registering without in any way interfering with the conductor itself the number of times that a lightning conductor is struck. It is of very simple construction; a cast iron box with suitable lugs carries the working parts, consisting of a simple iron bar which is magnetised by the current in the conductor, and deflected against the control of a spring, moving the hand on one division; a screw stop prevents its moving more than the right amount. All the works are fastened to the cover of the box so as to be easily accessible, and the sensibility is so arranged that a momentary current of at least 250 amperes is required to move the pointer.

Electric Car "Fenders."—The frequent accidents arising from the introduction of high-speed electric cars has led the inventive American mind to devise an appropriate form of "car fender." The form of "fender" now in use on the line between Lynn and Boston is a frame of ∿-shaped steel wire, the lower bar being covered with rubber. It may be run close to the track or lifted high above it, the height being controlled by a releasing device operated by the knee of the motor-man. Repeated trials on dummies placed on the track have, it is said, demonstrated that this "fender" will pick up man, woman, or child, and carry them along without harm, no matter in what position they may be when struck, or what the speed of the car may be. We are not informed whether the individuals so transported are taken free of charge.

The Electric Lighting of the Southampton Free Library.—At a meeting last week of the Southampton Free Library Committee, the Librarian stated that for 26 days the consumption of gas was 13,500ft., or an average of about 515ft. per day. The number of lamps of 16 c.p. was 67. The consumption of gas per hour was at first 207ft.; but Messrs. Crossley were not satisfied with that, and they sent down their chief inspector, who succeeded in reducing it to about 200ft., and it was anticipated that this would be succeeded by a further reduction. Whereas for lighting they now incurred an annual expenditure of £96; if they burned gas the cost would be £100; but inasmuch as in ten years' time the plant would be their own property, as it would then have been paid for, the £96 would be reduced by £47. 10s., representing a saving of nearly £50 a year.

A Coal Dust Engine.—A novel motive-power engine, says the *Engineering and Mining Journal* of New York, has been patented by a German engineer, and it is said that Herr Krupp is now constructing an experimental engine to test its practicability. The engine is based upon the fact that very finely divided carbon, floating in the air, readily explodes, and to adapt this to the generation of motive-power the inventor proposes to grind coal to an impalpable powder, and, after introducing the dust floating in the air into the cylinder of an engine, explode it, the idea being to follow very much the same lines which are being so thoroughly developed in the use of gas in engine practice. The first difficulty which suggested itself is how the ash is to be got rid of; but Herr Krupp says that his experience in gun manufacture convinces him that this is not a serious obstacle.

Non-Inductive Resistances.—At a recent meeting of the Société Française de Physique, M. E. Ducretet described a method he had employed for making high resistances without self-induction, and hence suitable for use with a telephone in Kohlrausch's method of measuring resistances. He uses a zigzag formed on platinised glass, very like that composed of fine platinum wire used by M. Mergier, and finds that a piece of platinised glass 75mm. by 110mm., allows of the construction of resistances varying from 25 to 100,000 ohms. The glass plates are fixed in a glass vessel by means of an insulating cover, and this vessel is filled with purified petroleum, which M. Pellat has shown to be a very good insulator. In this manner all effects due to moisture in the air are removed, while it is easy to measure the temperature. A layer of mercury of variable thickness at the bottom of the vessel allows of the resistance being adjusted to any desired value.

Electric Street Car Ambulance.—St. Louis, says the *Street Railway Review*, seems to have a quicker appreciation of the adaptation of the electric railway than any other city. She started with a postal mail car, the first of its kind in the world, and now proposes to put in service an ambulance car. The idea originated with Dr. George Homan, the city health commissioner, and promises to become a most important auxiliary in the work of his department, the object being to displace horse vehicles in conveying patients to the hospitals. The three large hospitals of St. Louis are some miles distant from the central part of the city, where the city dispensary is situated, and from which place all cases are forwarded. All the hospitals are in near relation to, or directly on the route of, one of the principal railway systems of St. Louis, and this fact was one of the considerations that determined the employment of this class of vehicle for the purpose stated. Of course, a special car will be required, and extra springs will be placed under the car body to make the journey as smooth as possible.

A Suggestion.—A correspondent in the Southern Hemisphere—it is not necessary to name the country—sends us the following suggestion. As we do not presume to understand it, we print it exactly as he wrote it. Lord Cross's committee, with the assistance of experts and Government scientific officers, might have made something of it. A committee of Section A of the British Association might be appointed to determine whether the "dry place" or the batteries themselves should be 6ft. high:—

"Observing in a recent issue of *The Electrition* an account of the friction that exists between the Electric traction Coys and the Telephone Coys in England it has occured to me that if the Telephone Coys would use Insulated airial wires on a metalic circuit it would obviate the difficulty. Get one of the Telephone Coys to try the following; run Hoopers tape covered wire (or any other well insulated wire) the whole length of the worst section they have, the wires may be run on the existing poles and brackets but as a precautionary measure when the present wires are disconnected from the Instruments they might be connected to the nearest known good earth, have the batteries standing in a dry place, about six feet high covered in and well insulated from the ground; this ought to prevent all induction from the other Coys wires, and it ought to reduce the danger

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when using the Telephone during a thunderstorm to a minimum. Have the Instruments fitted up in a room where deafening has been used all round, they might also erect a protecting board over the Instruments at such a heighth that the persons using them could stand upright and move with freedom, this will protect the Microphone from all exterior noises such as from engines factories etc. I am confident that if the above is carried out they will find that the noises complained of will wholly cease."

The "New Beacon Non-Infringing" Incandescent Lamp.—The rapidity with which perfectly "new," entirely "non-infringing" incandescent lamps are by pressure of circumstances being brought out in the United States is positively alarming. Here we have the Beacon Vacuum Pump and Electrical Company of Boston, not content with having evolved a non-mercurial air pump for exhausting glow-lamp bulbs, and having temporarily upset the Edison monopoly, now offering the public yet another lamp. In this lamp the neck of the bulb is provided with two shoulders, supporting two thin mica discs. The upper disc serves as a support to a cement plug, which is poured in in a fused state, and completely fills the upper part of the neck. This cement, we are told, "is of a novel composition, and is not only absolutely impervious to air itself, but makes an equally air-tight union or joint with the glass surface of the lamp neck. It is able to withstand the temperature to which it is subjected in the operating lamp without leaking or giving off any gases or vapour whatsoever." Notwithstanding this, however, the function of the lower mica disc is to act as a reflector and "throw back the heat of the filament, thereby keeping the cement plug from being affected." Not only so, but in the space between the two mica discs, are four small circular metallic discs strung upon the leading-in wires, which are of iron, and the function of these, we are told, is to "take up the heat of the leading-in wires and disperse it by radiation, preventing it from being carried into the cement plug." With much care bestowed upon the single point of keeping the cement plug cool, the statement that "while the lamp is burning the cap and socket are nearly as cool as when it is not in operation" ought certainly to be correct.

Electric Travelling Crane at Creusôt.—At the works of MM. Schneider et Cie., of Creusôt, a series of electrically-driven cranes have been constructed and put in operation. The first was an adaptation of a 45-ton rope-driven crane, the second was a 60-ton crane, and the third—a detailed account and numerous scale drawings of which are to be found in a recent number of *Engineering*—is a 150-ton crane, specially constructed to work by electricity. This crane is fitted with two 45-kilowatt continuous-current motors of the Ganz type. The current is supplied to these by means of two bare copper cables running the entire length of the parallel supporting girders. These cables rest on the tops of porcelain insulators supported on brackets; and they pass through hollow carbon brushes or collectors, by means of which the current is circuited through the motors. As these hollow brushes pass the porcelain brackets the copper cables are lifted from their position on the brackets. The generator is a 100-kilowatt four-pole Ganz machine, and it supplies the motors at 220 volts. Both the generator and motors are compound-wound. The attendant's cabin, in which the machinery is manipulated, is made of iron plate and angle-irons, and is fixed below the main girders of the traveller; and all the levers and regulating hand-wheels are so grouped that manipulation is easy and as rapid as may be desired. The power is communicated from the motors to the hoisting chain, or to the travelling wheels, as the case may be, by means of helical gear, worm gear, and chains. The chains are composed of built-up steel links with solid steel pins. Three sets of friction clutches enable the hoisting gear to be worked at 3·05ft., 8·23ft., and 11·84ft. per minute respectively, according to the load. These clutches are controlled by forked levers operated by nuts and screws. A band-brake is fitted to the first motion shaft of the crab, and is normally in action. To raise or lower a weight, the gear is first thrown into action, and the brake is then released by means of a foot-lever.

India Rubber Cultivation.—The *India Rubber World* of New York has an article on the lessons that the successful cultivation of the cinchona tree has for those interested in the rubber trade. "By the cultivation of the cinchona tree the world has been assured against exhaustion of the supply of an invaluable remedy, and the price has been reduced until it is no longer profitable to gather free bark and carry it to market. Besides, bark richer in quality has been produced on the plantations. While the cultivation of rubber has attracted little favourable attention so far, no objection has been made to its practicability, that might not have applied with equal force to the cultivation of quinine. The native supply of cinchona trees was so great that exhaustion long seemed impossible; certainly no cultivated product could compete with bark which could be had free, with the cost added of cheap labour for gathering it; perhaps the cultivated bark, in a distant land, would be less rich in alkaloids; besides, a great deal of time would be required for any returns from the investment in planting." Now, it is not known what would be the effect of cultivation upon the india rubber tree with regard to quality, but with regard to quantity Mr. F. O. Harriman's experience in Telmantepec is instructive; on his plantation the cultivated trees are twice as large in diameter as trees of the same age in adjacent forests. "The chief point to consider with regard to rubber culture," concludes the *India Rubber World*, "is not whether we are in danger of exhausting the native supplies—though that has become a practical question in some countries—but whether rubber might not be produced more cheaply under cultivation than it can now be gained in the forests. In addition to the convenience of gathering cultivated rubber, it would be possible to prepare it for market without a great part of the impurities now contained even in the better grades, thus rendering it more desirable for manufacturers. The cultivation of quinine is worth further study for points which may afford suggestions bearing upon the future methods of rubber supply."

A Laboratory Hot-Wire Instrument.—In a recent issue of the *Electrical World* Prof. A. S. Kimball describes a modification of the hot-wire voltmeter used in the laboratory of the Worcester Polytechnic Institute. Four No. 34 German silver wires hang from the ends of adjusting springs placed at the corners of a square hole cut in the top of a tall wooden box. At their lower ends the two wires hanging from the same side of the box are joined by a silk thread, which passes around a thin, loose pulley. The wires on the opposite side of the square are joined similarly by a thread on a second pulley. The wires *diagonally* opposite each other are in metallic connection at their lower ends. From the axis of the two pulleys hangs a plate of metal, with mirror attached. The lower end of the plate hangs in a dish of water to damp its vibrations. If a current be passed through one pair of diagonally opposite metallically-connected wires, the elongation of these wires will allow the suspended systems to rotate one way, and in the opposite direction if the current is sent through the other pair. In fact, the heavy plate has a double bifilar suspension, with oppositely directed couplers, and rotation is caused by varying the length of either pair of suspensions. If both pairs of suspending wires be elongated equally by the same or equal currents, there will be no rotation if the wires are similar and the suspensions are symmetrical. Any desired degree of delicacy may be obtained by regulating the length of the wires, the diameter of the pulleys, &c. Temperature errors are practically eliminated. There are no pivots or delicate moving parts to get out of order. The pulleys do not turn on their axis in use. They only serve to secure equal tension on the wires in the first adjustment of the instrument. The directing force is gravity, and the suspended plate may be made heavy enough to secure perfectly definite indications. Some of the uses to which this instrument may be put are obvious. For example, an alternating current on one pair of suspension wires may be balanced by a direct current in the other wires, and this may be measured by an ammeter. If a suitable switch be used by which the direct and alternating currents may be exchanged on the suspensions, any error of inequality of wires, or want of symmetry in the suspensions may be detected, and the adjustments corrected. In a similar manner, a direct current voltmeter may be used for the measurement of alternating electromotive forces. The sensitiveness may be estimated from the fact that, with the instrument described, which was designed for comparatively large currents, eight volts give a deflection of 256 millimetres on the scale at the distance of one metre.

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ELECTRIC MOTIVE POWER.*

BY ALBION T. SNELL.

(*Continued from page 464.*)

It is thus sufficiently clear that a parallel system requires conductors of larger section than those necessary for a series system; and a compromise involving a series transmission and a parallel distribution, is at once suggested.

Let us examine the various methods a little more in detail.

The simple parallel system is shown in Fig. 27. In this the whole of the current necessary for motors *b*, *c*, and *d* has to traverse the two conductors included in the section of the line *a b*, and that required for motors *c* and *d* has to pass through section *b c*, while *c d* only carries the current for motor *d*. Now, the areas of the conductors in the several sections of the line will be suited to the maximum or more probably the average current required to pass through them. There will, therefore, be a different pressure of supply at each of the points *b*, *c*, and *d*. This in itself would not matter if the actual values remained

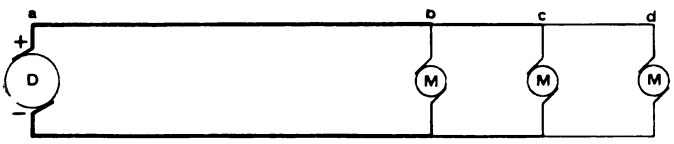

FIG. 27.

constant, but since the pressure of the line varies inversely as the current, it follows that the pressure will be lowest when the three motors are each absorbing their greatest current, and that it will vary at the several points of supply according to the current at each. And the speed of a motor is *proportional to the pressure of supply* for given currents, and therefore the speed will decrease as the load increases from this cause, as well as from the loss over the internal resistance of the motor, which is necessarily greater at large than small loads.

This difficulty is enhanced if the distance from the dynamo to the first motor, from thence to the second motor, and from there to the third motor, &c., be considerable—indeed, in that case, a limit is very soon reached, when the system hopelessly breaks down from the difficulties of regulation already referred to, and from the cost of the enormous weight of copper required to keep the line drop and loss within practicable bounds.

If it be required to cause the pressure at different parts of the circuit to vary approximately equally, the arrangement shown

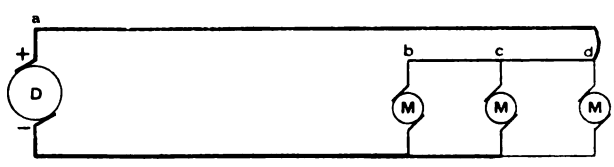

FIG. 28.

in Fig. 28, which is sometimes useful in lighting circuits, may be adopted; but the weight of copper in one of the feeders is evidently increased, and if the distance *a b* be at all considerable compared with *b c* and *c d*, the variation of pressure in the feeders may be so great as to practically outweigh the better regulation gained over the distributors by the looped wire. The scheme at best is but an approximation, and only likely to be used in cases where the motors are not grouped but lie conveniently in a line. In practice, since they are much more likely to lie in a group with some point fairly equidistant from the majority of them, this point will be selected as the centre of distribution, and the pressure there will be maintained as nearly constant as possible; and each motor or group of motors will be run on separate distributors, the areas of which will be so calculated with reference to their length and to the maximum or average current, that the maximum or average fall of pressure will be fixed between reasonable limits.

This brings us to the feeder system (*b*) shown in Fig. 29. As before, *a* represents the dynamo, or say the power station if there be a number of dynamos in parallel, *a b* represents the transmission mains or feeders, *b* the centre of distribution and the point at which the pressure is to be maintained constant; and *c*, *d*, *e*, *f* and *g* severally represent motors at the ends of distributors *b c*, *b d*, *b e*, *b f*, and *b g*. Let the pressure of distribution be fixed at 300 volts at the point *b*, and let the feeder efficiency at full load be 10 per cent. *i.e.* a drop of 30 volts is permitted along *a b*. The pressure at the power station will be 330 volts at full load, and will fall as the load is decreased until the smallest output is reached, when the pressures at the station *a* and the distributing centre *b* will be approximately the same. The fall of pressure in each of the distributors may be regulated according to the class of work

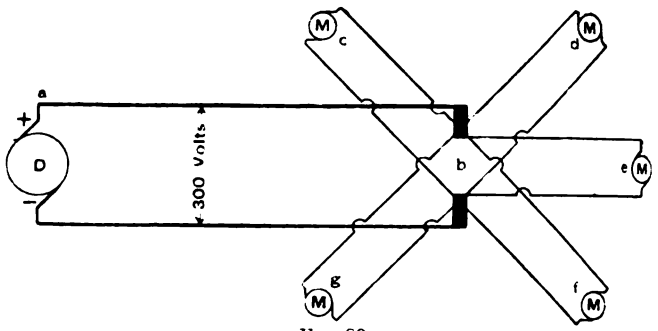

FIG. 29.

and regularity of speed required—an average drop of about five per cent. will usually be permissible for power work. The efficiency of the entire line will be therefore say, 85 per cent. under these assumptions; but it must be remembered that the conditions selected are entirely arbitrary, and the economic limitations discussed in previous sections have not been taken into consideration in any way whatever.

The next practical point bears on the limiting distances through which power can be efficiently transmitted. The two-wire feeder and distributor system (Fig. 29) has already been examined, and it is clear that the distance of transmission is practically fixed by the pressure of supply. Now the pressure of the distributors cannot be greater than that permitted by the conditions of supply to the consumers—500 volts will probably be the maximum pressure. But there is no such restriction to the pressure between the feeders; and hence

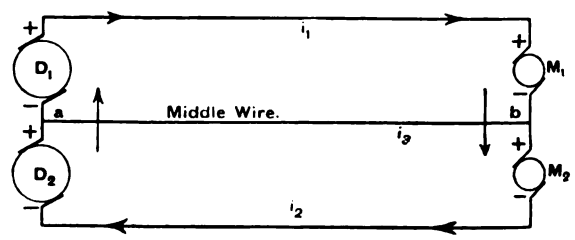

FIG. 30.

the *three*-wire feeder system shown in its simplest form in Fig. 30 is evolved. In this, essentially, two dynamos are coupled in series across the feeders, each giving, say, 500 volts and 50 amperes, and thus making a line pressure of 1,000 volts.

At the end of the feeders two suitable motors are also coupled in series, and a third wire is coupled to the junctions of the dynamos and that of the motors as is indicated in the diagram. The path of the current, when the motors are equally loaded, is shown by the arrow heads, and it is seen to be entirely confined to the machines and the two outer conductors, the middle or third wire carrying no current. But if one motor absorbs more current than the other, the difference between the two currents will pass through the centre wire. Let i_1 be the current in the circuit D_1 M_1; i_2 that in the circuit D_2 M_2; and i_3 that in the middle wire. Now when $i_1 = i_2$, then $i_3 = 0$; and also when $i_1 > i_2$, then $i_1 - i_2 = i_3$. When i_2 is zero, *i.e.*, when M_2 is not running, then $i_1 = i_3$ and the middle wire has to carry the whole current in the circuit D_1 M_1. In such a case it is not advisable to make the middle wire of less section than the two outer ones; but if M_1 and M_2 each represent

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a group of motors, it is reasonable to assume that full load on one circuit and no load on the other will be unlikely to occur at the same time, and, therefore, the middle wire will have to carry only the difference between the two currents. In practice, with a load of lamps, it is found to be sufficient if the area of the middle wire be half that of one of the outer wires. And it should be recollected that if the distributing centre be a large one it will be provided with suitable switching arrangements for transferring part of the load on the distributors from one circuit to the other, as may be necessary to secure a proper balance, and to keep the current in the middle wire as small as possible.

Assuming the load to be so arranged that it will be generally divided nearly equally between the two circuits, and that full load will never be on one and no load on the other, it will be safe to follow lighting practice and to make the middle wire of one-half the area of the outer ones. This will permit a difference of load in the two circuits sufficiently wide to meet the requirements of practice. Now it is seen that, for the same output from the power station the three-wire system requires twice the pressure and half the current necessary in the simple parallel systems shown in Figs. 27 to 29. And if the same gauge of wire be used the weight of copper in the three feeders will be 25 per cent. greater than that of the two, being in the ratio of 5 : 4; but since the middle wire is nominally idle and the outer feeders carry only half the current in the two-wire mains, it is clear that for equal conductors, output (twice

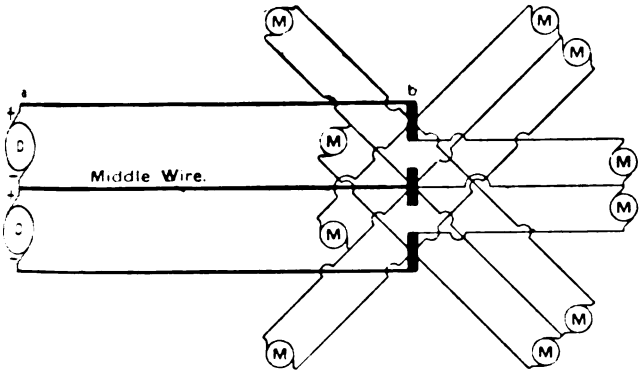

Fig. 31.

the pressure and half the current), and distance (between points *a* and *b*), the power lost in them will be only one-quarter with the three wires as with the two wires, and the fall of pressure will also be only half as great. For *equal conductors* and the same drop of pressure, the three-wire may be therefore twice as long as the two-wire system ; and for equal line loss or feeder efficiency and the same percentage of drop, four times as long. And if the relative weight of copper for *equal lengths* be considered, since the area of each outside conductor is one-half, and of the middle conductor one-fourth, of the area of either conductor in the two-wire system, the ratio of total weights will be as 5 : 8, showing a net saving of 37½ per cent. in favour of the three-wire system.

This system is evidently capable of extension, for let four wires be used and coupled to three dynamos and three motors, the pressure may now be 1,500 volts over the outer feeders and the current only 33·3 amperes ; and if the outer mains have the same section as before, the distance through which the power may be transmitted with the same drop is again raised by 50 per cent., or is three times as great as that with the parallel system, and the weights of copper for equal lengths are as 1 : 2. At Manchester a five-wire system has been erected for lighting to the specifications of Dr. J. Hopkinson. The outer mains are at 420 volts approximately, and between each of the pairs there is a pressure of 105 volts. Such a system is not likely to be used for the feeders of a power plant.

The three-wire system is applicable to the distributors as well as to the feeders, and is an important means of reducing the fall of pressure in the distributing net-work (*see* Fig. 31) which represents the disposition of feeders, distributors, and motors. It is apparent, however, that the three-wire feeder system, as well as the two-wire, ultimately reaches a limit beyond which it does not pay to transmit power ; for though the pressure may be raised almost indefinitely as regards the feeders, it is not so with the distributors—500 volts being probably a maximum for the supply service even in power work.

The next step is a pair of high-tension feeders coupled to a *regulator*, which may be a motor having as many armatures on the same shaft as there are sub-circuits, and feeding each pair of distributors at the desired pressure. These sub-circuits may be coupled on the multiple-wire principle. The general idea is shown in Fig. 32. In this diagram the armatures are sketched as if they were independent of each other. But in practice they are rigidly coupled or built on one shaft and essentially run in magnetic fields of the same strength and direction (or they may run in a common field). The arma-

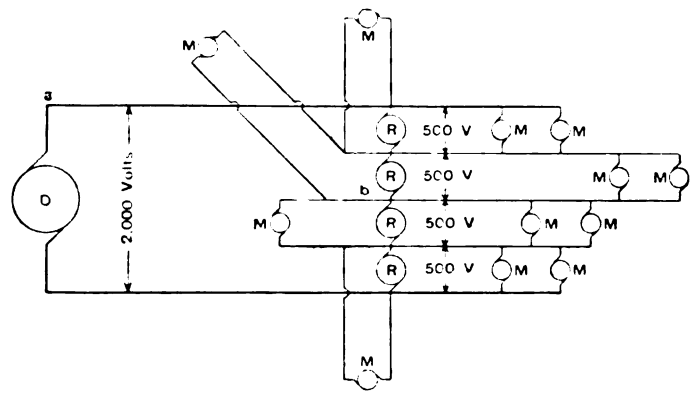

Fig. 32.

tures are of identical construction, and their internal resistance is made as low as possible. The field excitation is preferably supplied from an independent source such as accumulators, which may be charged in parallel across one of the sub-circuits at suitable times. Normally, when the load is equally divided between the sub-circuits, the four armatures absorb just sufficient current to overcome friction. But when one of the circuits takes more current than the others the armature in shunt to it will tend to lag. And the armatures in parallel with the other circuits will resist this alteration, and being coupled to the lagging armature will spend power in keeping the speed constant. Thus the lagging armature will be driven as a generator and supply the increase of current to *its* circuit, and the necessary power for the increase of torque will be supplied from the generating station. The degree of regulation attainable with this device depends on the internal

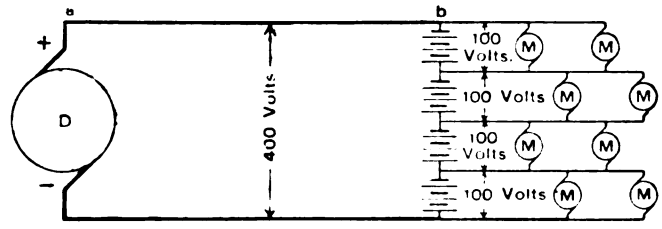

Fig. 33.

resistance of the armatures ; and it can only be efficient when the pressure lost over the armatures is negligible. The regulator principle is capable of considerable modification, and is likely to be used in one of its many forms for lighting in cases where the feeders are of great length.

Secondary batteries have already been used with undoubted success, in connection with three-wire distributors for central station work, by Mr. Crompton and others. The method is illustrated in Fig. 33. It will be apparent that the secondary battery acts as an accumulator as well as a regulator, and can be arranged to store up energy during periods of light load, which will be available for temporary outputs exceeding the rated engine and dynamo power ; and also in many cases the accumulators can deal with the small loads during parts of the early morning, and the steam plant may be shut down for that period.

(*To be continued.*)

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ELECTROLYSIS AT DEFINITE ELECTRICAL PRESSURES.

BY BERTRAM BLOUNT, F.I.C., F.C.S.

Since attention was recently called to the relation of the decomposition of salts of different metals to the pressure of the current used in their electrolysis, and to the methods of separation that could be founded on this relation—facts which, as indicated in these columns, are in no way new, but merely apparently novel on account of their persistent neglect—considerable activity has been displayed in extending and defining the knowledge thus exhumed. The latest contributor to the subject is H. Freudenberg, writing in the *Zeitschrift für physikalische Chemie*, the gist of whose observations, together with the comments they suggest, may be set down as follows:—

The view now fashionable, that a solution contains the dissociated ions of the salts present therein, involves the adoption of the belief that electrolysis of such solution can be effected by a current of indefinitely small pressure, the sole function of the current being dirigent. The data upon which this theory depends are both too limited and too particular to warrant its being regarded as more than a working hypothesis, of merit, indeed, but in wholesome competition with its kind for audience and acceptance. Moreover, it applies strictly to solutions of infinite dilution, and there is reason to suppose that as the usual limits of dilution are approached, other forces, nearer in their nature to those involved in ordinary chemical reactions, modify or abrogate the dissociation of the ions of dissolved salts. Taking, then, the more generally applicable hypothesis that there is a critical pressure of decomposition for each electrolyte, we are confronted with the fact that for the smooth electrolysis of a dissolved salt the pressure employed must be below that at which the electrolysis of its solvent begins. In the case of water, the commonest solvent, this pressure has a value of about 1·70 volt when the substance in solution is an acid or a base, but another figure is found for solutions of neutral salts Thus the value for a solution of sulphuric acid is 1·76, for caustic potash 1·67, for potassium nitrate 2·16, for sodium sulphate 2·21, and for zinc sulphate 2·35. The determination of the decomposition of water itself, when uninfluenced by the presence of dissolved substances, is difficult on account of the extremely high resistance of approximately pure water, and the doubt whether any observed result may not be due to a trace of impurity in solution. However this may be, a practical application of the difference in behaviour of salts of various classes is immediately possible.

Metallic salts, such as are commonly electrolysed, have been long tacitly, though not explicitly, divided into three groups: those from which the metal cannot be separated by the electrolysis of their aqueous solutions, *e.g.*, the salts of the alkalies, alkaline earths, aluminium, and chromium; those from which the metal can be deposited as peroxide at the anode, such as lead, manganese, and thallium; those from which the metal can be thrown down at the cathode, which include all that have been investigated in this connection with the exception of the members of the first two classes. It is among these latter that separations by variations of the pressure of the current used in decomposing their salts can be effected.

For experimental purposes, where a fairly close measure of the volts employed is required, a thermo-electric battery presents the advantage of yielding a nearly constant pressure, so that for the work now under discussion the time-honoured Daniell and Bunsen were set aside in favour of a Gülcher battery. Needless to say, the futile practice of reporting the volume of "bang-gas," evolved in a voltameter in circuit with the decomposing cell, was not adopted, as a measure of the total energy expended was not required, but only one of the intensity of that energy. It is highly desirable that experimenters would once for all abandon a method of stating their results which is a mere anachronism nowadays. Precipitation was effected in platinum dishes exclusively, so that no complications from independent action of the electrolyte might arise. The following are some of the separations attained by these means.

Silver was separated from copper in a solution of the nitrates of the two metals, containing free nitric acid, with a current having a pressure of 1·3 volt. Under the same conditions silver only was thrown down from a solution containing bismuth. With 1·7—1·8 volt silver was separated from arsenic, and at 1·2—1·3 volt from antimony, and at 1·6 volt from cadmium. Similar separations were obtained of silver from zinc and platinum, and mercury from copper, bismuth, arsenic, antimony, and cadmium, as well as of copper from cadmium and arsenic at 1·85—1·9 volt. It is noteworthy that the pressure needed to precipitate copper from most of its solutions is 1·8 volt, while from a solution containing oxalic acid 1·1 volt suffices. This observation gives cause for reflection. It has, of course, long been recognised that the deposition and separation of most metals succeeds best from particular salts, which are generally prepared *in situ* by adding to a solution of the sulphate, nitrate or chloride of the metal, an alkaline salt of the particular acid, *e.g.*, oxalic, hydrocyanic, acetic, &c., the compounds of which, with the metal to be deposited, is found best fitted for electrolysis, but hitherto little systematic study has been directed to the determination of the precise pressure needed to deposit a given metal from each of the salts which are found to yield it in a reguline form fit to be weighed. When a complete series of figures of this kind has been worked out, methods of separation by electrolysis, both for analytical and industrial purposes, will be greatly improved. Such data will be useful, not only for metals of the class that can be deposited from the aqueous solutions of their salts with the stronger acids, but also for others like iron, nickel, and cobalt, which have to be treated in alkaline solution as the pressure needed to decompose their ordinary salts in acid solution lies above that necessary for the electrolysis of water, inasmuch as the critical pressures for those double salts, *e.g.*, those of nickel and ammonium, and double cyanides, can then be utilised for the separation of members of this group after they have been obtained free from the more easily deposited metals already spoken of.

It will be seen from this account that progress is being made in the science and practice of electrolysis on thoroughly sound, because quantitative, lines. The days when disjointed qualitative observations of electrolytic phenomena were tolerated and even deemed acceptable are gone for ever, as completely as they are in the field of purely electrical research.

THE SALÈVE ELECTRIC RAILWAYS.

The Salève electric railways were the first mountain railways, that is to say, those utilising the rack, on which motive-power was supplied by electricity. They are intended for establishing rapid communication between Geneva and the different villages along the Salève, Mornex, and Monnetier, well known health resorts; and, moreover, for carrying tourists at Treize Arbres to view the mountain panorama. From the plain, two lines start; one from Veyrier, the last village on Swiss territory in that direction, goes to Monnetier, passing along the picturesque Pas de l'Echelle; the other, more specially made to serve Annemasse, has its origin to Etrembières, and goes round the Petit Salève, passing through Mornex, which has two stations, and arriving at Monnetier, where the two lines meet. A more alpine appearance is then assumed, the slopes are steeper, and habitations are no longer met with. The terminus is reached in 45 minutes, either from Etrembières or from Veyrier. The difference of level is about 900 metres on a length of six kilometres. It was consequently impossible to utilise ordinary adherence rolling stock, and it was decided to use the Abt rack, with a single rack on the lightest grades, and a double one when the grades become heavy, that is to say, on most of the length. Metallic sleepers are used, and are strongly fixed in a bed of thick broken stones. The rails, which are of the Vignoles type, weigh about 20 kilogrammes per metre run. Sleepers, rails, and racks are electrically connected together, and serve as conductor for the return current. The connection between

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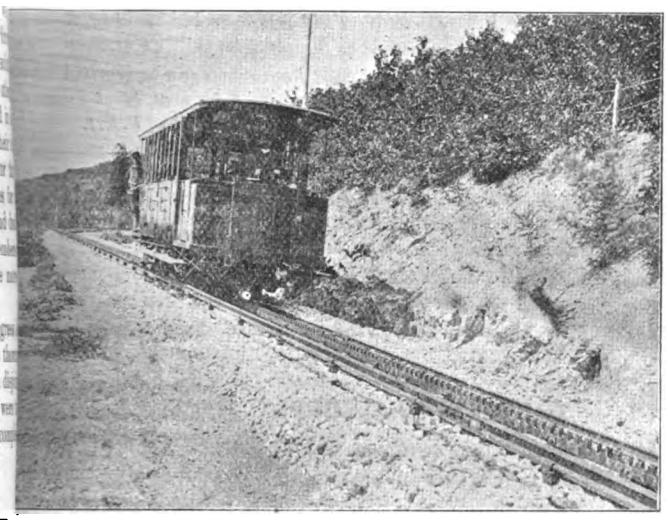
e different parts of rails is ensured by copper strips carefully ldered at each end.

The current is brought along the line by another Vignoles il with the plane face upwards. This rail is maintained at out 50cm. above the ground by means of iron rods fixed at e extremity of the sleepers. These rods support at the per end a strong porcelain insulator. On this insulator, but parated from it by a piece of lead sheet, is fixed a metallic llar supporting the rail. The different sections forming the nductor are also electrically connected by means of copper ips, and this conductor is totally interrupted on short ngths, in order to leave a certain freedom for expansion and ntraction. The arrangement is such that the connection th the rail still takes place by one at least of the two ntacts provided on each car, the surface of these contacts ing made large enough to carry the whole current required the car without overheating.

The generating station is placed on the Arve, near the conence of the Viaison. A good mill site was chosen at a very arp curve of the river. By excavating a short tunnel for e tail race, a fall of three metres was created, without any ed for constructing costly dams. The volume of water ailable averages 35 to 40 cubic metres per second. The ation is located on the right bank of the river, and is of suffint size to accommodate three turbines and dynamos. At



Salève Railway; showing Car, Rack, and Insulated Rail.

e present moment two only are fitted. The turbines are rtical engines, built by Rieter, of Winterthur. They are of e Girard type with partial injection. At a speed of 45 revotions per minute each of these can develop a maximum of 0 H.P. and drives directly a dynamo.

The dynamos, which are on the Thury system, have each elve poles, and are arranged to develop 1,000 H.P. at 180 relutions per minute. These machines are separately excited, eir field winding receives normally a current of 45 amperes. ne weight of this winding is 1,450 kilogrammes. The magtic field generated in the air-gap has an average intensity of 500 C. G. S. lines. The cores are made of wrought iron and e pole-pieces of cast iron. The internal boring is 2,500mm.

The armature, which is of the hollow drum type, bell shaped, formed by uniting segments of iron sheet and insulating by per and varnish. The width of the armature is 15 centietres, and its depth 45 centimetres. It is wound with the hury multipolar winding, composed of 451 coils giving a eight of copper of 178 kilogrammes. The collector has a ameter of 1·8 metres, and is composed of 451 sections of hard awn copper insulated with mica. The current is collected means of 48 carbon brushes disposed in sets of four on elve arms. The machine delivers 600 volts and 280 amperes 45 revolutions per minute. Its weight is 18 tons.

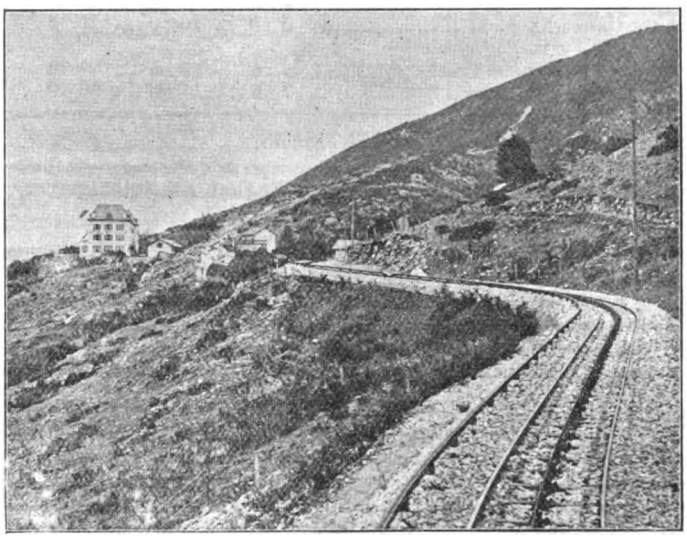
The current required for the excitation is supplied by a ecial dynamo driven by a 15 H.P. turbine. The regulation the voltage on the line is obtained by varying the excitation, that variation being effected automatically, by the action of a regulator acting upon the excitation, and by the action of the main current, which passes through a part of the exciter's field winding, and tends to increase its magnetic field as the current on the line increases. By this means the voltage is maintained fairly constant on the line, whatever may be the variations of current.

Where the line leaves the generating station lightning arresters are placed, to preserve the machines and apparatus. These arresters, consisting of condensers and impedance coils, are simple and effective.

The conductors connecting the generating station and the line are 1,800 metres long, and are supported on wooden poles. Each of them has a sectional area of 430 sq. mm. They are connected to the line at equal distance from Veyrier, Etrembières, and Treize Arbres.

The cars contain 40 seats and are supplied with two 40 H.P. motors. These motors revolve at 600 revolutions per minute, are electrically connected in parallel, and gear on the rack by means of a double reduction gearing, which reduces the speed in the ratio 13 to 1. According to the grade, the cars run between 1·5 and 3 metres per second.

The current is collected on the rail by means of two contacts on each side of the car, only one pair making contact at



Salève Railway; showing Arrangement of Rails and Rack, and Steep Gradients in the Distance.

once. These gun-metal contacts are very massive, and are provided with springs, ensuring a good connection in spite of vibrations. The return current passes to the rails by the wheels and the truck of the car.

Before reaching the motors, the current has to pass through lightning arresters and resistances, by means of which the speed may be regulated and a gentle start secured. The commutator, which is controlled by the driver, is provided with contacts, by means of which the resistance in circuit may undergo wide changes. Another apparatus permits of reversal of rotation of the motors; and an ammeter placed near the driver gives indication of the behaviour of motors.

The current required for lighting the car is supplied by a shunt on the main current. Five lamps are used, all connected in series with a suitable adjustable resistance.

For cars running on grades of 25 per cent., and even 30 per cent., the question of supplying good brakes was of the utmost importance. Three methods have been tried.

The first one consisted in changing the direction of the current in the motors, so causing a sudden stopping. It is not much employed on account of the violent shocks it occasions. The second one consisted in using the motors as generators under the effect of the declivity, sending their current through the resistances. The third one is a mechanical brake provided with a circulation of water. The different stations are connected together, and with the generating station, by telephonic lines.

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Editorial, Publishing, and Printing Offices :

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All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed "Coutts and Co."*

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THE ELECTRIC SUPPLY OF TIME.

It is so customary to designate as electric *light* companies the various undertakers of electric power supply that there is some risk of our forgetting that the scope of these undertakings is a far more extensive one than the name connotes. Indeed the limitations imposed upon so-called electric light undertakers are practically nothing more than the supply of ampere under a specified condition of volts. Without giving way to the wild speculations of popular science, which sees in electric supply the "open sesame" to a physical millennium we may recount numerous applications of public current supply to other purposes than lighting, which are either now realised or are commercially potential; and the gradual extension of which is ever tending asymptotically to render the term "electric light company" a complete misnomer. Already we find publicly-supplied current employed to develop mechanical power for a wide variety of purposes, and one of the latest developments is the use of an electric supply for regulating a system of clocks. This last application which occurs in Berlin, where the local electric supply company has adopted, for the benefit of its customers, a system of electrically-controlled clocks, invented by VON HEFNER ALTENECK, yet another instance of the comparative facility with which the public outside the United Kingdom can be induced to take up new ideas of this kind. Climatic conditions perhaps render impracticable the floating of a company to supply London like St. Louis, with ammonia for cooling in summer, and with steam for heating in winter; and other equally solid reasons would no doubt account for the poor outlook that there is in this country for electric motors and electric cooking. Even

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the measure of success which has attended the efforts of the London Hydraulic Power Company is relatively small, and the English municipality which should propose to spend the ratepayers' money, and at the same time assist the day-load in a microscopic manner by erecting electrically-controlled clocks, as was once, and may be still is, done in Brussels, at nearly every street corner, would inevitably succumb to the combined indignation of ratepayers and watchmakers. In short, the day when the sturdy individualism of our London public clocks, not to mention that of the so-called domestic time keepers, will be disciplined beyond recall by timely impulses from Deptford, is as yet far distant.

Although in Berlin they have now got as far as to employ the electric current in dispensing the most important of the three fundamental physical quantities, the conception of time is in reality very far from simple; it arises from the sequence of events, and depends on the observation of intervals between successive phenomena, and it is worthy of notice that this complete dependence of the time-consciousness upon "something going on" would render it absolutely impossible for us to detect a temporary stoppage of the universe, or in any way to gauge the period during which it remained absolutely passive. Newton, it will be remembered, in his empirical definition of mathematical time, conceived it to flow at an absolutely steady rate, unaffected by the speed or slowness of the motions of material things or by our states of consciousness. Floating, as it were, at equal distances on this steady stream of time are the indications by which we arbitrarily measure it, and chief among these we notice that fictive quantity, the mean solar day. The duration of the mean solar day, as our astronomical text-books will tell us, is determined by the interval between two successive meridian transits of an ideal or imaginary sun. Owing to this basis of time measurement there is a definite geographical variation of the instant of any particular transit. In devising a system of time, then, the choice lies with one of three courses: either to determine the commencement of the day at each place by the transit over the meridian of that place, and thus to adopt local time at each locality; or to fix upon one particular line of longitude as the standard meridian for every locality, and thus to adopt universal time; or else to combine the two systems. If we were rooted to the ground like trees, local time would be the most valuable; if we could travel from England to America in a fraction of a day, universal time would serve us best. In the present state of evolution and civilisation we compromise and adopt the last-named course. Now, the institution of a central time bureau implies the existence of some connecting link between the bureau and every timepiece within the boundaries of its influence. No clockwork mechanism is infallibly regular in its action; and few of us but forget to wind it up occasionally. The existing common link is crude, and consists mainly in setting a timepiece "right" by another which is equally liable to be wrong. The ideal link would consist in an actual regulating force applied by the central clock to every timepiece. Only in a very imperfect degree has this ideal been realised. At Greenwich there exists a mechanism which propagates an electric current to various points in London and other cities, which, at prearranged intervals, will wipe out the accumulated errors of the clocks at these several points; but, with our usual slowfootedness, the system of electric control from Greenwich has not been extensively used.

In the system now in vogue in Berlin the clocks are both propelled and controlled by the current from the electric power central station. Each clock is provided with a mainspring, which conserves sufficient energy to keep the clock going for twelve hours; but, in the normal state of affairs, this mainspring is kept fully wound up by an electromotor of simple construction. The large capacity of the spring is intended to obviate the disadvantages, which would arise if the clock depended on the state of the house fuses. Every morning at exactly 5 o'clock, there is a 10 per cent. fall of pressure on the mains, the object of which is to bring the regulating gear into action and correct the time-reading of the clock. This gear is only affected by variations of pressure at about 5 a.m., so that there is no liability at other times of a sudden load on the mains putting the hour hand of every clock to 5. Why 5 o'clock in the morning is the hour chosen for the purpose of regulating the clocks it is not easy to discover. True, there are but few lights on the mains at this time; but it is probable that these are on important service. Five a.m. is the hour when vitality is at its lowest ebb, when disease is most active, when suicide is most common, and so on. Is it for these reasons that a 10 per cent. drop of pressure is inflicted on the lamps at 5 a.m., when noon would seem to have every advantage in its favour? The essential objection to the Berlin system is that it restricts the area of control to very much narrower limits than the area over which the particular system of commercial time operates. The range of an electric supply company is at best a large town or a slice of a large city; while the range of any system of commercial time extends many scores or hundreds of miles on either side of the meridian. Nevertheless, the Berlin system has its merits, for it offers to the consumer time which, if not perfect, is at any rate as perfect as his neighbour's, and it brings to the supply company a class of consumer which requires a steady, even though small, supply of electric power.

THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 473.)

In working with French or German glass, which does not contain lead, no great attention need be paid to the flame, and any part of it may be used. As, however, lead glass is used almost always in lamp-making, it is necessary to take care that the flame is a suitable one, called sometimes a "clean" flame. That is to say, it must be one in which the "reducing" and the "oxidising" parts are clearly defined and are not mixed up. Figs. 24 and 25 show the forms of the cannon and the pointed flames respectively. The "reducing" flame is that part marked B. It contains an excess of carbon, while in the "oxidising" flame, C, there is an excess of oxygen. These different parts of the flame can be easily distinguished by their appearances. The hottest part of the flame is just at the junction of B and C, at the tip of the point of B in Fig. 34.

In working with lead glass, the oxidising part C can alone be used. If the glass is held in B, some of the lead is immediately reduced to the metallic state, and colours the glass black. When this takes place it is at once seen by the lead appearing as a bright red opaque patch on the otherwise nearly transparent glass. If allowed to cool, the patch will be found to be black. When this patch of lead appears, it can easily be oxidised again by holding it further away in the C part of the flame. This, however, can only be done if the patch is superficial. If the lead has been reduced much below the surface, it is impossible to get the glass clear again. The

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reason for being so particular about the inner or wind tube of the blow-pipe is that a tube which is irregular in any way will impart its unevenness to the air blast, so that the oxidising and reducing parts of the flame are all mixed up, or rather there is no oxidising part. Blow-pipes with metal wind tubes, which may be purchased ready made, are generally unsuitable for lead-glass working on this account.

The blow-pipe is fixed on the table about four or five inches from the edge, and pointing directly away from the operator. The table should be covered with a thick sheet of asbestos, and this should be painted black, as the flame can be seen much better against a dark background. The glass-blowing table should not be brilliantly lighted, and the light should come from above, or from the sides, and not from in front of the operator. If there is too much light, it is difficult to see the flame, or, at any rate, the oxidising part of it, which is almost entirely non-luminous.

There is one objection to the cannon form of blow-pipe for large flames. It is very noisy. In a room with a number

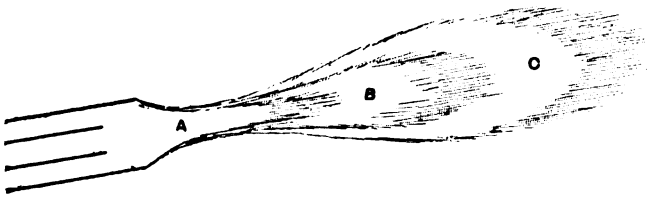

Fig. 24.

of them at work it is a matter of some difficulty to hold any conversation, on account of the powerful roar which they make. The small pointed flame (Fig. 25) makes, however, no noise whatever, and for this reason it is better to use a compound blow-pipe made up of several small noiseless flames. This may be accomplished by fixing three or four blow-pipes giving such flames side by side, and directed so that the tips of the flames meet each other. To obtain a greater heating power, an equal number may be arranged opposite to the first set, in the reverse direction, so that all the tips of the flames meet in the centre of the space between the two sets of blow-pipes. In this way is produced an excellent and perfectly quiet blow-pipe flame, which gives a more even heating, the glass being heated on both sides at the same time, though this is not always an advantage. Such an arrangement, however, is only applicable to work which does not require a varying flame. It is suitable for sealing in

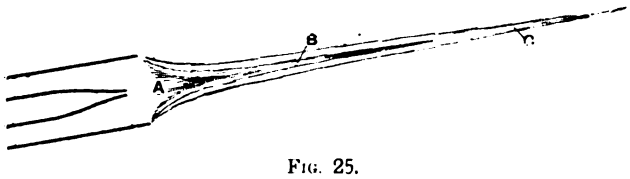

Fig. 25.

filaments, though the pump-maker could not work with it entirely. It is certainly an advantage to have the sealing-in room quiet. Six or eight cannon blow-pipes set up together in the way just described is, however, a rather clumsy arrangement. A better plan is to use blow-pipes of the form shown in Fig. 26. A is the gas tube, B is the air tube, each of which is provided with a stop-cock. At the top A terminates in a hollow burner, through which the gas passes by a number of small holes. The air tube B terminates in a glass nozzle C. The gas issuing from the top of A having been lighted, the stop-cock in B is turned, with the result that the air coming from C blows into the luminous gas flame and makes it assume the pointed quiet type of blow-pipe flame. Six or eight of these blow-pipes may be arranged so that the flames are combined together, as shown in plan in Fig. 27. The six pointed flames burn no more gas than the single cannon flame suitable for the same work would do; probably they burn less. The compound form is, of course, more costly in the first instance. There are stop-cocks, controlling both the air and the gas of the whole six burners, so that in case of any increase or decrease in the pressure of either, it is not necessary to alter the whole six or twelve cocks; in fact, when the stop-cocks in the pillars are once set properly they should not be again disturbed.

It is essential that the glass-blowing room be free from draughts, as a slight draught will blow the flame to one side, and render working difficult. As a consequence of this, the state of the atmosphere in a glass-blowing room with a number of blow-pipes working is often distressing to anyone but a glass-blower. There is no reason why a glass-blowing room should not be lofty and well ventilated, without any inconvenient draughts, but it is seldom the case. The author, not long ago, had an opportunity of going over a new lamp factory, the building having been constructed for the purpose, and was surprised to find that even under such circumstances the glass-blowing room had a very low ceiling, and no means of ventilation whatever. The quantity of gas used by a blow-pipe is very considerable, and the ventilation should, of course, be in accordance therewith.

Each glass-blower may, by means of a foot bellows, pump the wind for his own blow-pipe. This method has an occasional advantage in enabling him to vary the pressure, and, therefore, the form and heat of the flame without having to turn a cock. It seldom occurs, however, that one hand cannot be spared for an instant for this purpose.

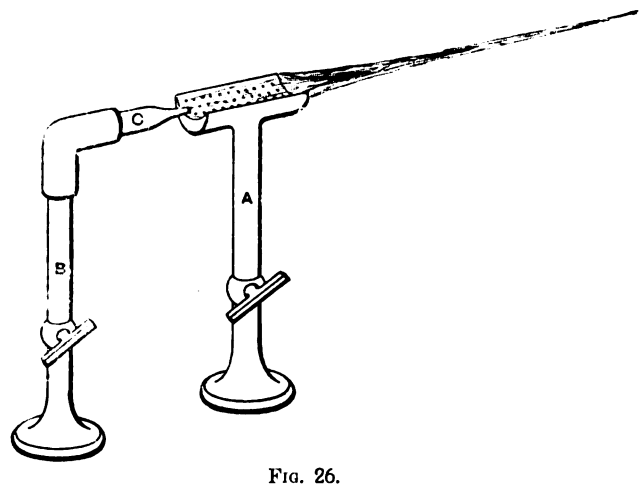

Fig. 26.

The disadvantage of a foot bellows is that the glass blower cannot sit so comfortably or steadily, both important considerations in glass-blowing, when he has to keep one foot pumping up and down all the while. Moreover, the wind is apt to run out at a critical moment. If a foot bellows is used, it is best to use a much larger one than the ordinary laboratory form, and to have it fixed underneath the table with a large air reservoir, in order that the blast may be steady, and not go up and down with each stroke. The bellows and reservoir should be large enough that a single stroke will supply the blow-pipe for some minutes. Such an arrangement, however, does away to a great extent with the advantage mentioned of being able to vary the force of the blast with the foot at any moment, which can only be done with a bellows of small capacity. In a factory where a large number of blow-pipes are required it is necessary that a supply of air be laid on so that the glass blowers do not require separate bellows. For this purpose, a mechanical pump with a single cylinder driven by power answers very well. The air is forced into an iron tank with a blow-off valve. The pressure may very well be five or six pounds to the square inch, and the blast will be perfectly steady if the reservoir is large enough. The force of the blast is, of course, entirely under control by the screw cocks on the blow-pipes. With an ordinary foot bellows the pressure is only a small fraction of this amount, but a much larger pressure in the pipes works perfectly well as long as the rate at which the air is admitted into the flame is under control. The air should be taken from the pump into the side of the reservoir, the bottom of which should be of such a form that any water inside may drain towards one

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part where a cock can be placed by which it can be let off. The delivery pipe should be led off from the top, so as to be as dry as possible. In damp weather there is always water condensed in the reservoir, and if it gets into the pipes it may cause trouble at the blow-pipes. Instead of a pump, a fan may be used. Fans, however, as usually constructed, are adapted for delivering large quantities of air at a small pressure, and are, consequently, unsuited for supplying air through long lengths of small piping. As a rule, they require a very high speed, and are very noisy.

As lamp bulbs blown from glass tubing have not altogether gone out of fashion the method of making them will be described. The cannon form of blow-pipe with the noisy flame is the best to use for this purpose. The size of the glass tube from which the bulbs are to be blown will be selected according to the size of the bulb which is required. For an ordinary sixteen-candle power size it will be about $\frac{3}{4}$in. in diameter, and about $\frac{1}{16}$th in. or rather more, in thickness. The tube must be quite clean inside and out, as any dirt may get burnt into the glass, so that it cannot be removed. The glass tubes are usually cut into lengths of about 3ft. The glass blower takes one of these, and sitting at the table with the blow-pipe just in front of him, he adjusts the size of the flame, using more gas at first than he requires for softening the glass, making thereby a flame much larger and not so hot as he will ultimately require. He then holds the glass tube with his left hand, so that one end of it is in the flame at some distance from the blow-pipe, at the same time turning the tube round and round so that it shall get heated evenly. The heating must be started gradually in this way, or the tube may crack.

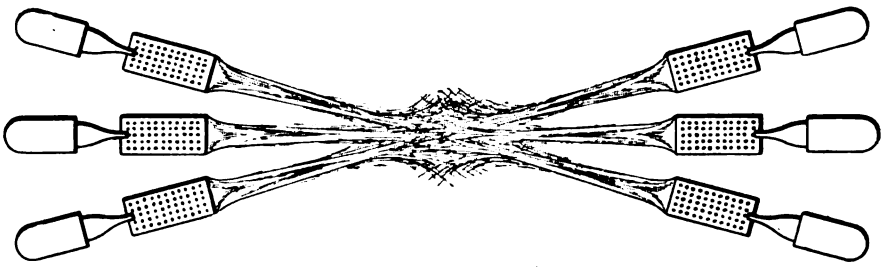

Fig. 27.

If the tube be a thick one it will be necessary to turn it round and round at a point beyond the flame altogether, so as to get it very gradually heated before it is brought into the flame at all. As the tube becomes heated the gas is turned down, thereby reducing the size of the flame, and making it hotter. The end of the tube, constantly being rotated, is brought into the oxidising part of the flame, and it soon begins to soften. When this occurs the glass blower presses the ends of the tube inwards with the tail end of a file or other convenient instrument, so that the sides touch one another. He then melts on a short length of small "cane" or "rod" glass. Having done this, he will heat the tube a little lower down, and when it is soft he will take it out of the flame, and, by means of the piece of cane glass, will draw out the heated part of the tube for 8 or 10in. or so, as shown in Fig. 28 (B). The part drawn out will be narrow and thin. When the tube on which the glass blower is working is long he cannot conveniently hold it up and work it at the same time. A rest must therefore be provided to hold one end of it. If the end is allowed to lie on the table it will roll along as the tube is rotated. The rest must therefore carry a groove or notch in which the tube can turn without rolling along. Having drawn out the end of the tube, the piece of cane used for the purpose is no longer required and may be detached. The tube is then heated about 3in. lower down and drawn out as before for 15in. or so, C, Fig. 28. This is done by means of the first piece drawn out, which, being thin, quickly cools enough to allow of handling. The tube is then cut at the centre of the narrow part of the second drawing out, leaving a piece of the original tube about 3in. long drawn out at each end into a small tube, D. The glass is cut by first scratching it with a file and then pulling it, when it will part at the scratch. The process of drawing out and cutting off is then repeated until the whole of the tube has been converted into pieces similar to D. Each of the pieces will make a bulb. The next operation is to close up one end by heating in the flame. This is easily accomplished, as the glass will close up of itself as soon as it becomes soft. When

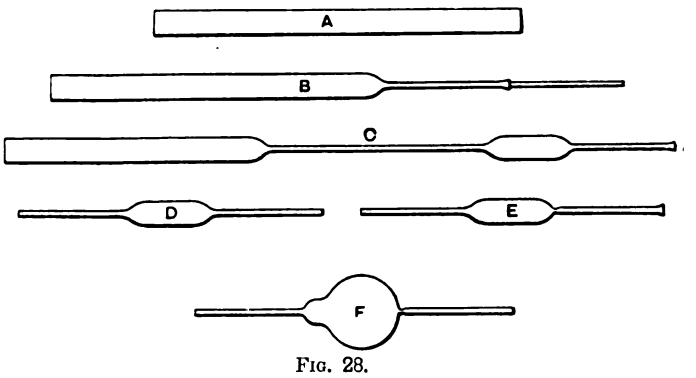

Fig. 28.

this is done, the narrow tube, which has not been closed, is heated close to its junction with the full-sized tube so as to make a contraction in the bore, E. This is the point where the lamp will be eventually sealed up after pumping. Nothing remains now but to form the bulb. For this purpose a rather larger flame is required, and is made to play upon the thick part of the tube, E, rather nearer to the contracted end than the other. As the glass softens it caves in all round, and the glass-blower pushes the smaller tubes inwards so as to get the soft glass into a smaller space, and so get it better covered by the flame. When it has attained the exact degree of softness, which is ascertained as much by the feel as the appearance, he takes it out of the flame, and holding it with the open end to his mouth in a horizontal position and quickly rotating it all the while, he blows into it with a series of short quick puffs, thereby blowing out the softened glass to any required extent forming a bulb, F. The bulb can be made of any shape according to the way the soft glass is manipulated and blown into. Success in blowing a bulb depends on the even heating of the glass and skill in manipulating it while it is being blown into. It takes a good deal of practice before a good symmetrical bulb can be made with certainty. Beginners invariably make one side larger than the other. If a large bulb is to be made from tubing a quantity of glass must be run together so that it is very thick at the place where the bulb is to be blown. This is accomplished by pressing the tube lengthways towards the softened part, thereby bringing in more and more glass into the flame. The exhausting tube of the bulb F should be closed up as soon as the bulb is finished to prevent dust from getting inside. Bulbs blown from tubing as described have this exhausting tube already attached. Pot bulbs, however, have no such tube, and one must consequently be joined on. This has to be done before the filament is put in, as the tube is necessary for holding the lamp during that operation. Tubing of the required size, about $\frac{1}{8}$in. diameter, is cut up into lengths of about 6in. An indiarubber cap is slipped over the neck of the bulb to make it air-tight. The end of the bulb

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where the exhausting tube is to be attached is then held in the blow-pipe flame, being rotated as usual, so as to soften a small part of the glass just in the centre. By the time this spot is soft, the air confined within the bulb has become heated, and therefore exerts a pressure outwards, which is sufficient to blow the softened part outwards and make a hole right through. The bulb is usually held in the flame and rotated by the left hand, while at the same time the right hand is heating the tip of one of the 6in. glass tubes. As soon as the hole appears in the top of the bulb the softened end of the tube is stuck over it, and the junction is held in the flame and thoroughly worked and melted together, and to assist the operation it is several times blown into and swelled out and reduced down again, finally being left contracted close to the bulb as in the case of the tube-blown bulbs. If the bulb is not required for use for some time the ends should be sealed up.

(To be continued.)

LANDMARKS IN THE HISTORY OF ELECTRO-CHEMISTRY.*

BY W. W. HALDANE GEE, B.SC., F.C.S.

In an age so essentially electrical it may be assumed that everyone is familiar with the favourite experiment of exploding mixed gases by an electric spark with the help of a contrivance known as Volta's pistol. This was a metal or strong glass vessel, sometimes a brass cannon fitted with an arrangement for passing a spark through the mixed gases with which the vessel was filled.

In April, 1781, Dr. Priestley using this apparatus and making what he terms a "random experiment" for the purpose of "entertaining a few philosophical friends," exploded air or oxygen with hydrogen in a closed glass vessel by means of the electric spark. It was observed that the sides of the glass vessel became covered with moisture, but no particular note of this circumstance was taken at the time. One of the friends who witnessed the experiment proposed to test by means of this apparatus whether "heat was heavy or not." For this purpose a copper flask was filled with air and hydrogen, weighed, and then the spark was passed. Great heat was evolved by the explosion, after the dissipation of which the flask was again weighed. After several trials it was concluded that a loss of weight occurred, and consequently that heat is a ponderable body. The experiment was repeated by that extraordinary man, Cavendish, time after time, in his laborious and accurate manner. His result was to negative the conclusion at which Priestley had arrived. In these experiments Cavendish used a strong glass vessel and confirmed Priestley's observation of the deposition of dew. This phenomenon he considered likely to throw light upon the question, at that time unanswered, as to what becomes of the oxygen which disappears during combustion. The explosion in the globe gave too small a quantity of liquid for satisfactory examination. He then used a larger volume of the mixed gas, and exploded it in a cylinder. The resulting liquid he found to be without taste or smell, and finally concluded that "this dew is plain water, and, consequently, that almost all the inflammable air and about one-fifth of the common air are turned into pure water." In the course of his experiments on the explosive combination of hydrogen and oxygen, Cavendish employed at different times apparatus of various forms. That used in the experiments mentioned above he describes as a glass globe furnished with wires for the passage of the spark, with a brass stopcock, and a means of attachment to the arm of the balance. The pear-shaped "Eudiometer" which forms the badge of the Cavendish Society (Fig. 1) is very different in construction. "Were Cavendish," says Dr. Wilson in his "Life of Cavendish," "alive among us, he would not recognise the modern instrument as resembling any part of his apparatus, and it would startle him to hear it called his Eudiometer." Yet in the cartoon of Mr. Ford Madox Brown at Owens College, Cavendish is represented as carrying an elegant pear shaped vessel. The apparatus presented to the Royal Institution by Sir Humphry Davy, and known as Cavendish's Eudiometer, has a completely different form (Fig. 2). It consists (according to Dr. Wilson—*see* "Life of Cavendish," 476) of a brass cylinder, about 6in. long and 2in. in diameter, fastened down to a piece of deal by means of two iron staples. The cylinder is closed at the extremity to the left of the figure by a plate, the centre of which is perforated for the reception of a stopcock for the purpose of connection with an air-pump to exhaust the vessel before filling it with the mixed gases. The bent piece of metal attached to the handle was probably for giving greater leverage

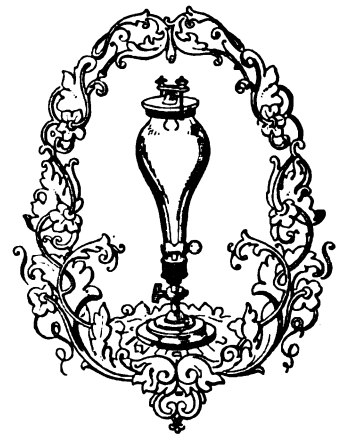

FIG. 1.—Cavendish Society's Badge.

and better control over the stopcock. There is a second stopcock furnished with a drawn out jet for the purpose of drawing off the water after the explosion. By the side of the opening for the stopcock is another aperture, into which is screwed a perforated nut containing a short piece of thermometer tube, the bore of which contains a wire passing into the cylinder. This evidently furnished the means of passing the electrical spark. The term "eudiometer" as applied to these instruments would be new to Cavendish. In his time it was restricted to the apparatus in which nitric oxide was mixed with air for the purpose of ascertaining the goodness of the air. Modern chemistry retains the eudiometer for gas analysis as a straight graduated tube with wires sealed into the glass for the purpose of passing the spark.

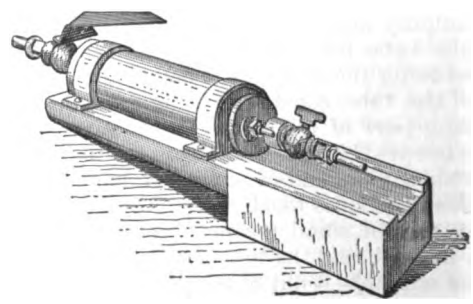

FIG. 2.—Cavendish's Eudiometer.

The liquid obtained by the spark experiments in which *air* was employed instead of pure oxygen was, however, found to be acid. Following up this observation, Cavendish made another important discovery, that of the composition of nitric acid, in which the aid of electricity was again invoked. Air was confined in a glass tube, bent at an angle which, after being filled with mercury, was inverted so that the open ends of the tube were beneath the surface of mercury in two glasses partly filled with this liquid. Air was then introduced by means of a bent tube of peculiar shape. Sparks were passed across the air. On introducing above the mercury a solution of potash a diminution of volume was noticed. More air was then introduced, the sparks again passed, and the process repeated until the liquid would absorb no longer. On evaporating the liquid to dryness, a white, solid salt-like sub-

* The substance of these articles was originally read at a meeting of the Owens College Chemical Society. For some help in preparing for publication I am indebted to Mr. Vaughan Cornish, M.Sc., F.C.S.

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stance remained, which Cavendish identified as nitre (potassium nitrate) by its property of forming touch-paper. By this and many auxiliary experiments Cavendish proved beyond the possibility of doubt that nitric acid is formed by combination of the nitrogen and oxygen of the air. It must be remembered that by an acid was meant, at this date, the substance we now term the anhydride, the body that is, which, on dissolving in water, forms the acid. The work of Cavendish must have been tedious in the extreme. He laboured at the frictional machine an hour a day. It is, indeed, not surprising that others failed in the experiment, and that, in consequence, doubt was thrown on the accuracy of his results. In reply to the statement of these doubts, Cavendish said that "as this experiment has been tried by some persons of distinguished ability in such pursuits without success, I have thought it right to take some measures to authenticate the truth of it." For this purpose several distinguished members of the Royal Society met together and repeated the experiment, at length, successfully. The discovery was finally established in 1788. Dr. Black, in his lectures, says of it: "This discovery of Mr. Cavendish is one of the most important in the whole history of chemistry." It was the last of Cavendish's published researches on chemistry. Thenceforth he devoted himself to the prosecution of other branches of natural science, and although he lived to see the brilliant achievements of Davy there appears to be no record of his employing the superior apparatus to be presently described.

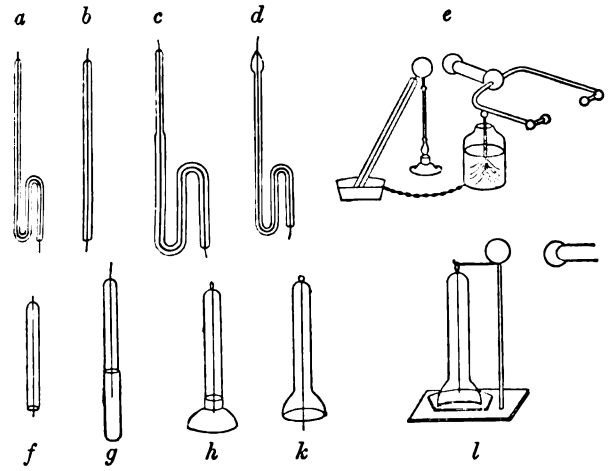

FIG. 3.—Different forms of apparatus for the decomposition of water by electricity.

The decomposition of water by electricity was first effected by Messrs. Paets van Troostwyk and Deiman, assisted by Mr. Cuthbertson. Their experiments are described in the *Journal de Physique* for 1789. Different types of apparatus employed by them are shown in Fig. 3, *a* to *e*. One form consisted of a tube 12in. long, with a bore of $\frac{1}{8}$in. in diameter, with a gold or platinum wire sealed in the top. Another wire, also of gold or platinum, was introduced into the open end of the tube, a space of about $\frac{5}{8}$in. being left between the wires. The tube was filled with distilled water, freed from air by an improved air-pump, and the open end was immersed in mercury. By means of a large electrical machine of two plates of 31in. in diameter, and a Leyden jar, electrical discharges were sent through the water, as shown by Fig. 3, *e*. Gas was liberated, and when sufficient had been collected to reach nearly the bottom of the upper wire, a discharge caused almost the whole of the gas to disappear, and water again filled the tube. The experiment was, however, a difficult one, and lacked confirmation until Dr. Pearson published his "Experiments and Observations, made with the view of ascertaining the nature of the Gas produced by passing Electric Discharges through Water," in the *Phil. Trans.* for 1797. He used an improved apparatus (*see* Fig. 3, *f* to *l*). A tube, about 4in. long and of about $\frac{1}{5}$in. bore is provided, as before, with a wire, which extends down to a brass tube, which it almost touches. Another kind of apparatus employed is also shown in Fig. 3, *h*. A glass tube, half an inch wide, has a brass funnel fixed at one end, but afterwards the tube was blown like a funnel (*see* Fig. 3, *k*), arranged in a brass dish (Fig. 3, *l*). The distance of the end of the wire from the dish was about one-twentieth of an inch. With this apparatus gas was obtained much more readily than with the original apparatus on account of the greatly lessened resistance. The experiments were, however, still very laborious, as the following extract from the description of the experiments show:—

"Experiment 1. At 0h. 40m. p.m. began to produce discharges with a double plate 24in. machine in water taken from the cistern; and at 12h. 6m. p.m. of the same day there had been written down 10,200 discharges, each of which occasioned air to ascend from the bottom of the wire and brass cup. The quantity of air obtained was now apparently about one-quarter of a cubical inch." Next day 6,636 additional discharges were passed. At this time "I was surprised on the passage of a discharge by a vivid illumination of the whole tube and a violent commotion within it, with, at the same time, the rushing up of water."

The general evidence of his experiments convinced him that oxygen and hydrogen were produced by electric discharges; and he remarks that "if experiments be proposed in which electric discharges must be passed through water or other fluids, for even a much longer time than was consumed in performing those referred to, or related in this Paper, it may be an object to employ the wind, or, perhaps, the power of a horse to turn the electrical machines, the expense of labourers being considerable."*

(*To be continued.*)

OCEAN TELEPHONY.

(COMMUNICATED.)

The question of long-distance submarine telephone cables is one which had already attracted attention, and recently, as our readers know, Prof. Silvanus Thompson read a Paper at Chicago on the subject. As it may sooner or later cause some alarm to proprietors in telegraph companies which own, to the value of 40 millions sterling, the ordinary form of submarine cable, it may be as well that the matter should be impartially considered in advance.

The idea that a merchant in London could converse direct with his correspondent in New York is no doubt a somewhat captivating one, especially as questions could be asked on both sides and explanations given to a degree not possible in practice with telegraphy. But careful reflection shows that there are even greater difficulties to the general use of suboceanic telephony than the mechanical and electrical problems which have still to be solved. To begin with, taking England, or, rather, the West of Ireland, and the United States as being the most favourably situated for the purpose, the difference in time (4 hours 56 minutes) would greatly limit the use of the telephone during business hours, because when it is 11 in the morning in New York it is 4 p.m. in London. Telegraphically considered, the concurrent working hours of the two places, therefore, do not exceed three per diem. Again, to earn a sufficient revenue on such a cable, the tariff for telephonic conversation would have to be so high as to be absolutely prohibitive. In the case of the wire between London and Paris the rate is 8s. for three minutes' talk. The fact is, as business men know by painful experience, that even between two parts of the same city there are many drawbacks to the use of the telephone. Frequently the line is engaged, the person one wishes to speak to is out or in another part of the building, the apparatus is out of order, or owing to deficient articulation, slight deafness, or cross talk, it is difficult to catch what is said. Some of these objections would apply with tenfold force to submarine telephony.

Again, it is exceedingly improbable that important transactions—and matters must be important to necessitate the use of an Atlantic cable—would be arranged by telephone, which leaves not the slightest record or evidence, and may be overheard by others. Coding in telephony is practically impossible. Next, there is no limit theoretically to the working of a submarine cable of any length, provided the amount of copper

* Wollaston, in 1801, showed that by using gold points as electrodes it was possible to decompose water by means of an ordinary frictional machine.

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and gutta-percha per mile are adequately increased, but the question of expense makes a line much exceeding 2,000 miles out of the question. No doubt a similar limit as to the length at which telephone cables might be workable would be found to exist. Applying this argument to telephoning from this country to Australia or New Zealand—where it is midnight at our noon—it will be seen that the message would have to be repeated at least eight times by operators who would know nothing of the subject matter, and some of them, possibly, be unacquainted with the language in which the message was originally spoken. It would be a very curious message by the time it was delivered, since there can be no question that the ear is much more easily deceived in regard to articulate telephonic sounds than is the eye with reference to telegraphic signals, which are moreover recorded, and the message after being written can be checked by the record.

It follows, therefore, that interoceanic telephone messages would only, if at all, be practicable over distances which enable the persons concerned to talk to each other. To imagine that the possibility of talking across an ocean (when already you can communicate in writing) is likely to cause a revolution in every department of life, or to give a powerful stimulus to trade, is simply to altogether over-estimate the probabilities of the case. Even if ocean telephony is found to be feasible, the number of telegrams now sent will be very little affected; and it must, further, be remembered that, if the idea be feasible, one, two, or three telephone cables across the Atlantic would be of very little use.

From the point of view of shareholders in existing submarine telegraph companies, it may be pointed out that if it be hereafter found that sub-oceanic telephony is possible, that there is a demand for it, and that it is commercially successful, there is nothing to prevent existing companies, some of which have very large reserves, laying suitable cables as an additional string to their bow. We can all appreciate the enthusiasm and perseverance which led to the successful laying of the Atlantic cables, because there were then no means of rapid communication, and it was absolutely certain that, once established, a very large number of telegrams would be exchanged; but where is the capital likely to be found for an experimental telephone cable which would only enable one to hear his correspondent's voice instead of reading the written message?

There are many instances in which inventions, especially where there is an element of sentiment, have been elaborated after great research, labour, and expense, with the result that it was found after all no one wanted them. This is not unlikely to be the lot of those who are turning their attention to sub-oceanic telephony. The experiment would have to be on a very large scale; in the case of the Atlantic it might cost nearly half a million sterling; and if it were found impossible to use the telephone, or, if capable of being used, there were no demand for it, the cable would be, as Prof. Thompson admits, probably useless for ordinary telegraphing, although it might be available for high-speed automatic, for which, however, taking his estimated speed of 400 words per minute, it is clear there is not sufficient traffic. Taking the average number of words in practice transmitted daily over a cable as 7,000, it will be seen that the automatic at 400 words per minute could transmit this number of words in about 20 consecutive minutes *if they were all handed in for transmission at the same time.* Perhaps Prof. Thompson's idea is that if the tariff were reduced to one fourth, the volume of traffic would be increased four or five fold, but all experience is against this. Even at 3d. per word people would not telegraph to America for the pleasure of the thing, or unless they had more or less urgent occasion.

Finally, before the subject is carried any further, it would be as well to ascertain if such a cable as Prof. Thompson describes could be tested, and the faults, which would undoubtedly occur, be localised. Unless such a method be found, it would be as reasonable to talk of telephoning to Mars. Prof. Thompson says that if it is possible to increase the speed of telegraphing eight-fold, a cable to effect this will certainly be made and laid, and certainly an increase of working speed would be very desirable during the busy part of the day; but a great deal could be done in this direction by laying cables of the existing type with very large cores, which would not cost nearly so much as an experimental cable of the kind described, and would permit of a considerable increase in speed in automatic working.

At the same time, it is to be hoped that those who have taken the matter up will continue their efforts to increase the speed of working long cables. It is certainly curious, as Prof. Thompson says, that the method of working now is practically the same as it was 20 or more years ago, and the writer has sometimes thought that the eminent position held by Lord Kelvin in the electrical world, and his unsurpassed knowledge of the conditions of submarine telegraphy may, perhaps unconsciously, have deterred cable men from attacking the subject boldly. On the other hand, it will certainly be no easy task to improve upon that beautiful and sensitive instrument—the syphon recorder. To those who understand the conditions of long cable working it argues no small amount of courage on the part of Prof. Thompson, Mr. Preece, and others that they should not only bring their great abilities to bear on the problem of rapid automatic working on long submarine lines by a new type of cable, but should endeavour to render possible sub-oceanic telephony.

A NEW INCANDESCENT ARC LIGHT.*

BY L. B. MARKS.

Electrical literature is replete with studies of the incandescent lamp as a source of artificial illumination; the performances of arc lights under a great variety of conditions have also been published from time to time. But the subject of the so-called incandescent arc, singularly, has received little or no attention. In view of this fact it has seemed desirable to report at once, on a series of investigations, which, though still incomplete, have disclosed some remarkably interesting and important phenomena with reference to a new form of incandescent arc light. The experiments have been carried on far enough to demonstrate that this source of illumination is *sui generis*. While possessing the main characteristics of the ordinary arc, it is also akin to the incandescent light, and may be said to constitute a mean between these two.

The incandescent arc has been described as one in which the "two electrodes are in imperfect contact," the current thereby meeting with a high resistance and producing heat effects, which manifest themselves in the incandescence of one electrode and the formation of a number of very small arcs between the uneven parts of the electrodes in contact.† On this principle, Reynier, Werdermann, Joel, Tommasi, and others, constructed lamps years ago, but for well-known reasons none of these "semi-incandescent" lamps, as they were called, found much practical application. The Sun lamp of Clerc and Bureau was a modification of the others, the arc impinging on the surface of a block of marble or condensed magnesia between the tips of the electrodes. In this form there was a rapid waste of the non-conducting substance interposed, and a diminution in the efficiency of the light.

The *incandescent arc* to be treated of in this Paper differs radically from any of the forms alluded to above. In it the electrodes are not in contact, while the current is indirectly used in maintaining all the products of disintegration of the carbon in a state of incandescence or opalescence.

Plate A shows the main features of the appurtenance. It will be seen that the arc is enclosed in a small envelope, which is made of highly refractory glass. The envelope is closed at the bottom and provided on top with a metal plug having an opening in it just large enough to admit of the feed of the upper electrode. A fireproof plug of asbestos-pulp insulates the metal from the glass. A valve, shown in the plate, allows the egress of gas, but prevents ingress of the air. With this construction the operation of the lamp will be as follows:—Upon the closure of the circuit, and the springing of the arc, the air in the enclosing envelope is robbed of its oxygen, the latter uniting with the carbon of the electrodes to form CO and CO_2 gases. The gases are brought to an exceedingly high temperature at which they maintain the carbon vapour issuing from the arc. This vapour is deposited in the form of a thin coating on the internal surface of the glass chamber. The expansive force of the gases may become sufficiently great, if no means of egress be provided, to rupture the envelope; hence, a small safety-valve is provided for their outflow. The only possibility of ingress of air is through the narrow space between the positive carbon

* Paper read at the International Electrical Congress, Chicago, August, 1893.

† Julius Maier: "Arc and Glow Lamps," p. 263.

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and the plug. Experience has shown that after the temperature has been raised beyond a certain point the amount of air that enters in this way is inappreciable ; in any event, the oxygen is immediately converted by combination.

It is important that the enclosing glass envelope be as small as possible, for the conservation of the radiant energy, and hence the efficiency will depend largely upon the size of the chamber. The heat which, in the ordinary arc light is dissipated in the air, is here conserved, and raises the temperature of the enclosed gases and vapour of carbon. The proper conditions being fulfilled, the lamp maintains its maximum efficiency shortly after the current has been passed through it, and glows like the incandescent with the brilliancy of the arc light. The arc proper is scarcely visible, but the entire contents of the chamber seem to be luminous, giving the appearance of a solid cylinder of light.

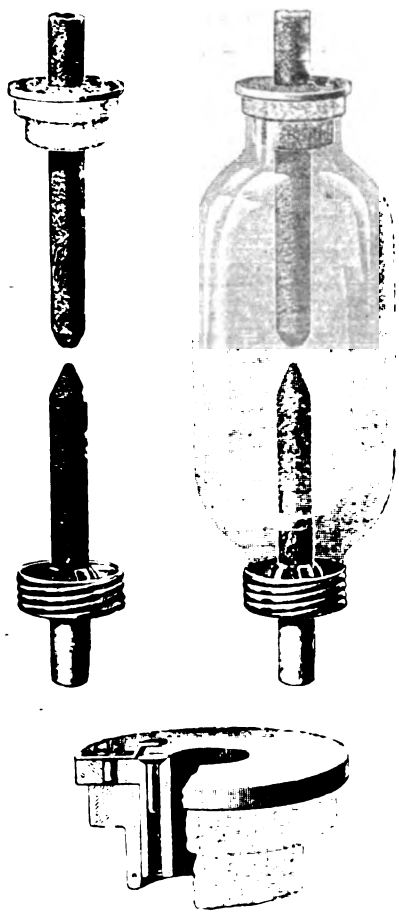

PLATE A.

The pressure, as well as the temperature of the enclosed gases, has a very important bearing on the performance of the lamp, and affects to a marked degree the character of the carbon deposit on the glass chamber. At this date no definite figures can be given, but it appears that a high tension is absolutely required to give good results. The structure and constituency of the electrode are also pre-eminently important. Absolute purity of the carbons is imperative.

Investigators in this field have apparently found it impossible to obtain all the requisite conditions. Beardslee* mentions a type of lamp similar to the one under discussion, but whether the size or character of the arc-enclosing chamber, the nature or management of the gases, or the quality of the electrodes, or other features made his arrangement impracticable, is not recorded. Suffice it to say, the comparatively poor grade of arc light carbon manufactured ten years ago would alone explain his failure.

It is interesting to note here that attempts have been made at various times to save carbons in arcs by excluding the oxygen of the air. Baxter† devised several forms of arc lamp with this object in view. The subject has been more recently referred to by Thomson‡. These experiments were attended with little practical success ; not because the desired ends were infeasible, but probably because, as in the case of Beardslee's apparatus, alluded to above, one or more of the requisite conditions had not been attained. It appears that the saving in life was more than counterbalanced by the loss in light. The "incandescent effect" was absent, and the unsteadiness of the arc itself was fatal. The results were almost identical with those obtained when the arc is formed *in vacuo*. In this case there is a tendency of the carbon to deposit as a soot on the sides of the vacuum chamber, an effect consequent upon the vaporised carbon in the arc being carried off and condensed again, as soon as the vapour escapes the heat of the arc stream. But the requisite conditions hereinbefore named being once attained, the arc is really a beautiful phenomenon. It differs in many respects from the arc in open air, being especially steadier than the latter. The light, emanating from the incandescent vapour of carbon, appears to issue from all parts of the small enclosing envelope, the area of the source of illumination being limited only by the size of the chamber.

Measurements of the efficiency and candle-power of the light were made in the laboratory of Cornell University. The method employed in making the efficiency tests was that used by Nakano* in determining the efficiency of the arc lamp, and subsequently by the writer in an investigation on arc light carbons.† The ratio of luminous to total radiation of the lamp was taken at different angles below and above the horizontal. The values obtained are given in Table I, where L equals luminous radiation, T equals total radiation, and $\frac{L}{T}$ equals radiant efficiency. Fig. 1 represents the curves plotted from these values, the dotted line curves showing the distribution of luminous and total radiation respectively, and the full line curve the measure of the efficiency below the horizontal. The value of the mean hemispherical efficiency is obtained by integrating the curve, and is found to be 8·4 per cent. The mean efficiency of the ordinary arc is about 10 per cent.‡ The

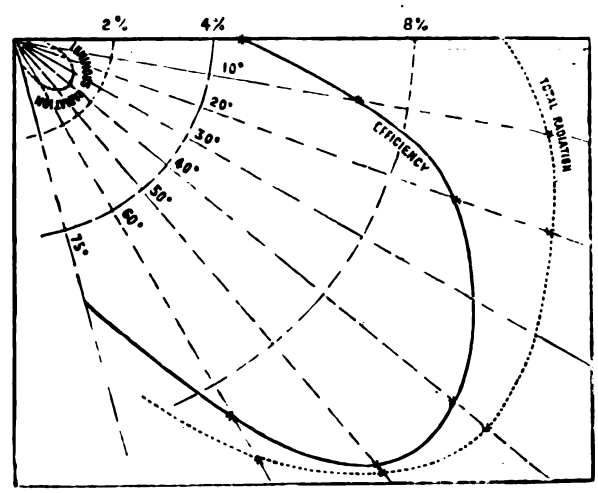

FIG. 1.

mean efficiency of the incandescent lamp, according to Merritt,§ is rather below than above 5 per cent. The value obtained in the test of this new light therefore lies between those of the two present forms of electrical illumination, approaching, however, more nearly that of the arc. While it is true that the average efficiency of the electric arc in open air nets is about 10 per cent., it is questionable whether in commercial practice in this country this value is often reached. The writer has made tests of a standard brand of arc-light carbon where the efficiency was only $7\frac{3}{4}$ per cent.||

Glancing at Fig. 1, we note that while the form of the efficiency curve differs entirely from that of the incandescent lamp, it is not unlike that of the arc. The distribution of light-giving energy is, however, more uniform than in the arc, a fact which is more prominently brought out in comparing the candle-power curves of the two. While the approximate law, *hemispherical efficiency*, $= 1/4$ *horizontal*, $+ 3/4$ *maximum*, holds for the ordinary arc, the mean of several tests indicates that *hemispherical efficiency* $= 1/2$ *horizontal* $+ 1/2$ *maximum*, fairly represents the conditions manifested by the

* G. W. Beardslee : U.S. Patent, 265,737, October 10, 1882.

† William Baxter, jun. : U.S. Patent, 288,157, November 6th, 1883 ; and U.S. Patent, 306,993, October 21, 1884.

‡ Elihu Thomson : "The Electric Arc and its Use in Lighting." Paper read before the National Electric Light Association, February 18, 1891. See also *The Electrician*, Vol. XXVI., p. 562, *et seq.*

* H. Nakano : "Efficiency of the Arc Lamp." *Trans.* Amer. Inst. Elec. Eng., Vol. VI., p. 208, 1889.

† L. B. Marks : "Life and Efficiency of Arc-Light Carbons." *Trans.* Amer. Inst. Elec. Eng., Vol. VII., p. 185, 1890. See also *The Electrician*, Vol. XXV., p. 150, *et seq.*

‡ H. Nakano : l.c.

§ E. G. Merritt : *American Journal of Science*, Vol. 37, p. 167.

|| *Trans.* Amer. Inst. Elec. Eng., Vol. VII., Nos. 5 and 7, p. 202. See so *The Electrician*, Vol. XXV., p. 150, *et seq.*

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incandescent arc, curves, Figs. 1 and 2. Tests were made to determine the effect of initially coating the surface of the cylinder with various ingredients other than carbon. No marked difference in the efficiency was discovered. Fig. 2, plotted from values in Table II., represents a curve taken in this way. The mean hemispherical efficiency was 8·02 per cent.

TABLE I.—*Efficiency Measurements.*

Mean current = 9 amperes. Mean potential difference = 55 volts.

Angle.	0°	-10°	-20°	-40°	-50°	-60°	+10°	+20°	+30°
L	7	12·3	17·0	22·0	20·5	13·5	8·5	7·0	7·0
T	155·0	175·0	180·0	195·0	180·0	155·0	135·0	135·0	135·0
$\frac{L}{T}$	0·045	0·07	0·094	0·113	0·114	0·087	0·063	0·052	0·052

TABLE II.—*Efficiency Measurements.*

Mean current = 9 amperes. Mean potential difference = 55 volts.

Angle.	-0°	-10°	-30°	-50°	-60°	+20°	+40°
L	10·5	12·0	14·0	15·5	14·0	10·5	8·50
T	155·0	160·0	170·0	150·0	140·0	155·0	150·0
$\frac{L}{T}$	0·068	0·075	0·082	0·103	0·100	0·068	0·57

TABLE III.—*Candle-Power Measurements.*

Mean current = 8 amperes. Mean potential difference = 63 volts.

Angle.....	0°	-10°	-20°	-30°	-40°	-50°	-60°	+20°
Candle-power...	218	283	455	590	595	515	450	170

Table III. gives the candle-power measurements from which the curve (Fig. 3) was plotted. Distances measured along the radii give the candle-powers for the various angles throughout the "zone of useful illumination." It will be seen that the distribution of light, as shown by the candle-power curve, differs considerably from that of the ordinary arc. Especially is this true at angles greater than 50deg. below the horizontal. The turn in the curve is not so sharp as in the arc, and there is much less difference between the maximum and the mean amount of light; in fact, to the naked eye the intensity of luminous radiation does not seem to vary much from 20deg. to 60deg. below the horizontal, while in the arc the change is very marked between these limits. Thus the formula of Gérard‡, namely, *hemispherical c.p.* = 1/2 *horizontal c.p.* + 1/4 *maximum c.p.*, which may be used to advantage in arc light approximations, will not hold in this case; but the form of the curve, as well as the nature of efficiency curves above referred to, suggests the substitute—*hemispherical c.p.* = 1/2 *horizontal c.p.* + 1/2 *maximum c.p.* The mean or hemispherical candle-power below the horizontal, obtained by integration of curve Fig. 3, equals 431, thus allowing 1/17 watts per candle, or 637/6 candles per electrical horse-power—nearly three times the average illumination of the incandescent lamp using the same energy. The results of tests show that the mean hemispherical candle-power of the ordinary arc, measured as in the above case, averages about 600; the mean watts per candle, 0·84 or 888 candles per electrical horse-power.

Comparing these measurements with those of radiant efficiency, it appears that the ratio *hemispherical c.p.*, "*incandescent-arc*"/hemispherical c.p. ordinary arc is considerably smaller than the ratio *hemispherical efficiency*, "*incandescent-arc*" hemispherical efficiency, ordinary arc.

The explanation of this difference undoubtedly lies in the quality of *luminosity* of the light omitted by the *incandescent arc*. Nichols‡ has pointed out that the relative efficiency, as determined by the ratio *luminous radiation*/total radiation, "does not coincide with that obtained from the ratio of candle-power to watts, for the reason that the various rays which make up the visible spectrum do not enter into the production of candle-power in proportion to their energy." Luminosity is a potent factor in determining the real efficiency of any source of illumination. Lack of time has prevented the investigation of this important phenomenon, but, at its maximum efficiency the light from this form of *incandescent-arc*, though not so intense, unmistakably appears brighter than that of an ordinary arc of equal candle-power as interpreted by the photometer.

‡ M. Gérard: "Candle-Power of Arc Lamps." *Centralblatt für Elektrotechnic*, January, 1890.

‡ Dr. Edward L. Nichols: "The Efficiency of Methods of Artificial Illumination." *Trans.* Amer. Inst. Elec. Eng., Vol. VI., No. 5, May, 1889. See also *The Electrician*, Vol. XXII., p. 601.

Oxygen being practically excluded from the arc enclosing chamber, prolongation in the life of the electrodes is an implied concomitant. In the ordinary arc "while the positive carbon loses by volatilisation from its tip or crater, and by combustion from its sides, the negative gains no deposit, but wastes at a less rate than the other, and by *combustion only*."‡ Hence, if the exclusion of oxygen were complete, we might expect an indestructible negative. This condition, however, has not been fulfilled in any of the tests made thus far, but the results fully substantiate the theory. Absence of combustion on the one hand, and the tension of the enclosed gases on the other, combine to greatly reduce the amount of disintegration of the positive electrode.

Table IV. gives the results of life test with a pair of pure carbons, 1/2 in. diameter, and specially constructed for the purpose. The lamp was placed in the circuit of a constant current dynamo, running about eight hours per day; readings were taken at given intervals, and the total length of run was limited to 100 hours.

TABLE IV.—*Life Tests.*—1/2 in. carbons.

Mean current = 9 9/16 amperes. Mean potential difference = 55 volts.

Initial length (+) carbon (in.).	Initial length (−) carbon (in.).	Duration of run (hours.).	Loss in length (+) carbon (in.).	Loss in length (−) carbon (in.).	Life per inch (+) carbon (hours).	Life per inch (−) carbon (hours.).
10·31	4·63	100·0	6·81	0·69	14·67	145·45

Thus making 1·69in. per hour as the average consumption of carbon in the commercial 350 watt-lamp, run at 5 1/2 amperes and 50 volts,† we note that although 525 watts, or one and one-half times the energy have been expended in the case of the lamp under consideration, yet the life per inch of carbon consumed is more than *twenty times* that of the other. Indeed the figures show that the life of the negative was nearly *one hundred times* as great as that obtained in commercial practice to-day.

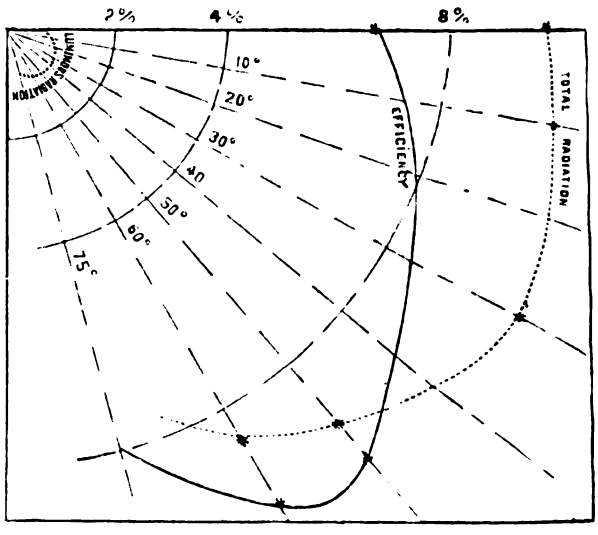

FIG. 2.

The preservation of the negative is a very interesting feature of this type of lamp. There is a marked tendency towards deposition of the products of volatilisation of the upper electrode, on tip of the lower, the carbon deposited, if not ruptured by the action of the lamp, forming an integral part of the negative. In one case, where the arc having been sprung the electrodes did not come in contact during the entire run, this "building up" process was beautifully exhibited, the negative electrode gaining practically all that the positive lost. The current in this instance was 10 1/2 amperes, and the potential difference 50 volts. The duration of the run was 11 hours.

The effect of the enclosed gases on the form and character of the arc presents a large field for investigation. On account of lack of sufficient data no attempt will now be made to state much of a definite nature regarding this subject; but it is hoped that the matter will be given due attention in the near future. The difference in potential between the electrodes being equal, the *incandescent arc* is longer for a given current than the ordinary arc

‡ Elihu Thomson, l.c.

† E. F. Peck: "Carbon Tests." Paper read before the National Electric Light Association, February, 1890. See also *The Electrician*, Vol. XXIV. p. 470.

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Under some conditions it has been found to be almost twice as long. If we accept the conclusion of S. P. Thompson, that "the arc is independent of the nature of the surrounding gas,"* we must then look to the effects of the tension or pressure of the heated gases upon the arc to explain this difference in length. It has been found that there is a constant increase of potential difference with pressure above atmosphere for a given current and length of arc.† But in spite of this fact the decrease in resistance of the arc under the conditions named appears to allow of a greater length for the same potential difference.

In the ordinary arc the carbon vapour carried off from the positive is consumed by the oxygen of the air before it can deposit on the negative. Hence the ever present "zone of flame," as distinguished from the arc flux proper, is really a zone of combustion. In the *incandescent arc*, however, there is naturally no zone of flame, consequently the phenomenon of *flaming* common to the ordinary arc does not occur. The arc tends to centre itself, being probably aided in so doing by the pressure of the surrounding gases; moreover, the slow consumption of the electrodes lessens the tendency to wander. With cored carbons there is a perceptible crater, but with solid pencils the tips become more or less flattened.

The quality of the carbon has an important bearing on the potential difference between the electrodes. Generally speaking, it has been observed that with soft fine-grained carbons the potential difference is considerably lower for a given current than with harder or coarse-grained pencils. The tendency to *hiss*, however, is not so marked when the electrodes are consumed in the gas chamber as in the open air; in the former case the disintegration is so slow that the "electrolytic" vaporisation, as it has been called,

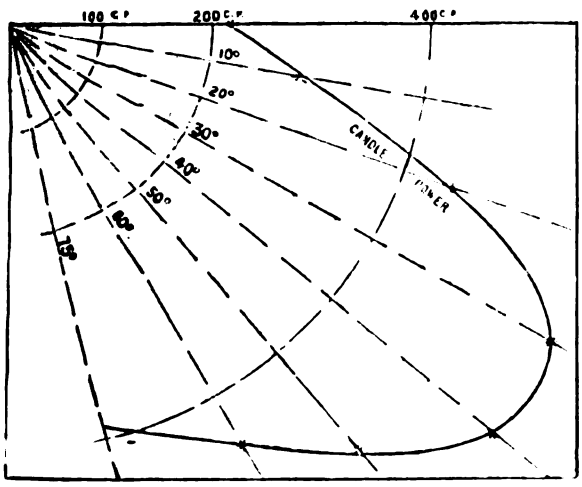

FIG. 3.

does not appear to explode the particle. It is interesting to note here that these results confirm a theory of *hissing* advanced by Prof. Thomson a few years ago.‡

No measurements were made using the alternating current, but the appurtenance was applied to the alternating-current arc lamp to determine the effect on the noise of the arc. The *hum* was in a large measure reduced, but whether the reduction was due mainly to the mere fact of the arc being enclosed in an air-tight compartment or not is questionable. But as the *hum* became much slighter after the lamp had been in operation several minutes, the action of the heated gases being then manifest, it is plausible that the diminution in the noise was not due entirely to the shielding property of the glass envelope. While it has been proven that "the humming of the alternating-current arc is due to the rapid periodic extinction and re-establishment of the discharge,"§ the singing tone may be greatly modified, if not entirely overcome, by the substitution of any incandescent arc of the Reynier type. A few years ago the writer had occasion to test an alternating current arc-lamp trimmed with carbons which had been provided with a core of pulverised mica and carbon. The springing of the arc was accompanied by the usual *hum*, but as soon as the mica fused the noised ceased. The conditions were similar to those of an *incandescent arc*, the plastic mica-carbon core constituting a high-resistance medium between the plus and minus electrodes. There was really no true arc. The amount of light was naturally greatly reduced. In the case of the *incandescent arc* first alluded to, there seems to be an approach to these conditions, the arc-stream acted upon by the gases enclosed in the chamber appearing to have a greater density, if we may call it that, than under normal circumstances. The amount of light in this experiment was, however, apparently as great as in the direct-current tests.

Unquestionably this form of *incandescent arc* must have a wide application to the arts. As a substitute for the ordinary arc light, where greater steadiness or longer life is required, its superiority will be manifest. And its utilisation, where at present the incandescent lamp is the only satisfactory source of illumination, also presents a large field. The effective distribution of luminous energy, and the colour of the light, make it for many purposes a desirable mean between the incandescent and the arc. As a standard source of illumination for arc-light comparison and measurements, it may be of much scientific, as well as utilitarian, importance.

The investigations have been carried out under the direction of Mr. Louis E. Howard, and many of the facts herein stated are due to him. The writer is also indebted to Dr. Edw. L. Nichols, Franklin L. Pope, and Robert H. Read for valuable suggestions; to Mr. C. Ransom for life tests, and to Messrs. Wm. C. Hubbard and E. S. Ferry for assistance in the efficiency and candle-power measurements.

* S. P. Thompson. "On the Physics of the Voltaic Arc." Paper read before British Association, Section A, Edinburgh, August, 1892 See also *The Electrician*, Vol. XXIX., p. 460.

† Dr. Louis Duncan, A. J. Rowland, R. I. Todd: New York *Elec. Eng.*, Vol. XVI., No. 274, p. 99, 1893. See also *The Electrician*, August 4th, p. 360.

‡ Elihu Thomson: *Trans.* Amer. Inst. Elec. Eng., Vol. VII., Nos. 8 and 9, p. 274.

§ Dr Edw. L. Nichols: "A Photographic Study of the Electric Arc." *Trans.* Amer. Inst. Elec. Eng., Vol. VIII., Nos. 6 and 7, 1891. See also *The Electrician*, Vol. XXVII., p. 139.

THE PRACTICAL MEASUREMENT OF ALTERNATING ELECTRIC CURRENTS.

BY PROF. J. A. FLEMING, F.R.S.*

(*Continued from page 478.*)

III.—*The Measurement of Alternating-Current Power.*

Having dealt in the preceding lectures with the subject of the measurement of alternating-current strength and alternating-current pressure, I propose to consider now the measurement of alternating-current power. When the current is flowing through a conductor it dissipates energy, and the rate at which this energy is dissipated is spoken of as the *power* taken up in that circuit. When a constant current is flowing through a conductor, if we measure the current in amperes and the difference of potential in volts, then the product of these two numbers gives us the power taken up in the circuit measured in watts. In this case two simple measurements give the required rate of dissipation of energy in the conductor. If, however, we have to deal with an alternating current, in which the current strength is varying from instant to instant, according to a periodic law, and if, likewise, the difference of potential between the ends of the circuit is varying in the same periodic manner, we cannot always obtain the measurement of the mean power taken up in the circuit, generally speaking, by taking the product of the $\surd$/mean-square amperes and $\surd$/mean-square volts. What we really require in this case is the mean value of the power taken up in the circuit. We can obtain the measurement of the mean power if we can measure at every instant the true value of the current strength and the difference of potential, supposing these instantaneous values of the current and pressure known at equidistant intervals taken throughout one complete period; if we then multiply the instantaneous value of the current by the corresponding value of the pressure, or difference of potential, and multiply these together, we obtain a number representing the instantaneous value of the power, and if we imagine the period divided into a large number of equidistant intervals of time, and those products taken at every such instant, then the mean value of these products, taken throughout the period, would give us a close approximation to the mean value of the power being absorbed by that circuit.

We have seen in a previous lecture how it is possible to determine and describe curves representing the instantaneous values of the current and E.M.F. in the case of an alternating-current circuit; but this in general is not a simple matter to do, and we have therefore to resort to other methods of obtaining the required result. In dealing with the power taken up in alternating-current circuits, there are two cases to be considered. The first case is that in which the circuit is non-inductive. In that case, as before explained, the impedance of the circuit is the same as its resistance, numerically speaking. For such circuits the alternating current flowing in the circuit is in step, as regards phase, with the alternating potential difference between its extremities. When this is the case the power taken up in that circuit can very easily

* Abstract of Cantor Lecture delivered before the Society of Arts, February, 1893.

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be measured. If we measure the √mean-square value of the alternating current by means of any of the balances of dynamometers, described in the first lecture, and if, by means of any of the electrostatic or thermal voltmeters, we measure the √mean-square difference of potential between the ends of the circuit, and multiply these two mean-square values together, we obtain the mean value of the power taken up in the circuit, and we arrive at the same result as if we had been able to measure separately the instantaneous values of the current and potential difference at numerous equidistant intervals throughout the phase, and taken the mean value of their products. As an instance of this, it may be pointed out that an incandescent lamp may be treated as a practical non-inductive circuit. If an incandescent lamp is traversed by an alternating current, and we measure the current flowing through the lamp by means of, say, a Siemens dynamometer, the potential difference between the terminals of the lamp by means of, say, a Cardew voltmeter, and if we multiply the two scale readings of these instruments together, we obtain the mean value of the power measured in watts, taken up in the lamp. So far, then, all is quite simple, and in dealing with any circuit which we know or can prove to be practically non-inductive, we have no difficulty, by means of two instruments of the proper kind, in determining the real mean-power taken up in the circuit. Our difficulties come in when we have to deal with circuits such as transformers, which, when not fully loaded, we know to be inductive. If, in this case, we can determine the instantaneous values of the current and difference of potential between the ends of the circuit, then, proceeding as above described, we can determine the mean value of the power taken up in the circuit. If, however, it is not convenient to do this, we cannot proceed to measure the √mean-square values of

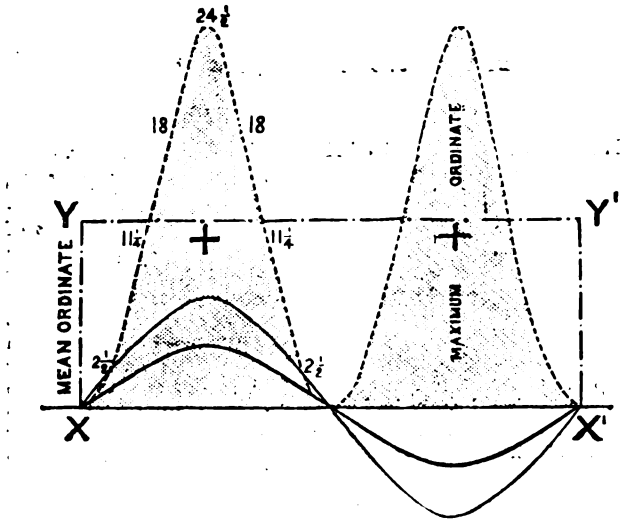

FIG. 10.

the current and E.M.F., and then multiply them together. Such a proceeding would lead to a considerable overestimate of the real power taken up in the circuit. Without going into elaborate proof of this, it may be simply sufficient to present the following figures :—

In Fig. 10 are shown two simple harmonic curves in step with one another. The semi-period is divided into equidistant parts, and ordinates are erected at each point. By squaring each of the values of the ordinates, and taking the square root of the mean of the squares, we obtain for each curve a number which would represent the instrumental value obtained by an alternating-current dynamometer or voltmeter. If we multiply together the simultaneous values of current and E.M.F., we obtain a number which represents the instantaneous value of the power taken up in the circuit, and if we take the mean value of all these separate instantaneous values of the power, we obtain the same number as we do if we take the products of the square roots of the mean of the squares of the instantaneous values of the current and E.M.F. Hence, we see that when the two simple harmonic curves are in step with one another, the product of the square root of the mean of the squares of the separate ordinates is equal to the mean value of the products of the corresponding ordinates.

In Fig. 11 are shown two periodic curves, which may be taken to represent a current and an E.M.F. curve, but one of which is displaced backwards relatively to the other. This is what happens in an inductive circuit, where the periodic current always lags in phase behind the periodic E.M.F. If we perform the same operations on the ordinates of these curves, we find that a product of the mean square values is in excess of the mean of the products. In other words, if in such circuit we measure the current by means of a dynamometer, and the potential difference between the ends by means of an alternating-current voltmeter, the product of these two numbers gives us a number which is in excess of the true value of the mean power taken up in the circuit. It is convenient to call the product of the √mean-square amperes and the √mean-square volts the *apparent watts* taken up by the circuit, and to call the true mean value of the power the *true watts* taken up by the circuit. The ratio between the true watts and the apparent watts is called the *power-factor* of the circuit. Thus, for instance, in the case of a transformer on open circuit, the transformer being of the closed-magnetic circuit type, the power factor is about 0·7 ; in other words, the real power is only ⅞ of the apparent power. In the case of a transformer of the open magnetic-circuit type, the power-factor may be as small as 0·1. Hence you see that an enormous error in this case would be committed by taking the product of the instrumental readings as simply representing the true mean power taken up in the circuit. We have, then, to consider in what way this true mean power can be practically measured in the case of alternating current circuits.

There are many methods by which this may be done. A large number of methods have been described which look very excellent on paper, but which do not in practice turn out so well. As I desire only to bring under your notice those methods which are capable of being practically employed, I shall pass over the theoretical methods, and turn at once to the description of those instruments which will enable us to measure practically the power taken up in inductive circuits. The most practical, and by far the best instrument to use for this purpose is the electro-dynamometer instrument. Consider a dynamometer, such as one of the Siemens dynamometers described in my first lecture. Let the fixed coil of this dynamometer be placed in series with the circuit in which we desire to measure the power being taken up. Let the movable cir-

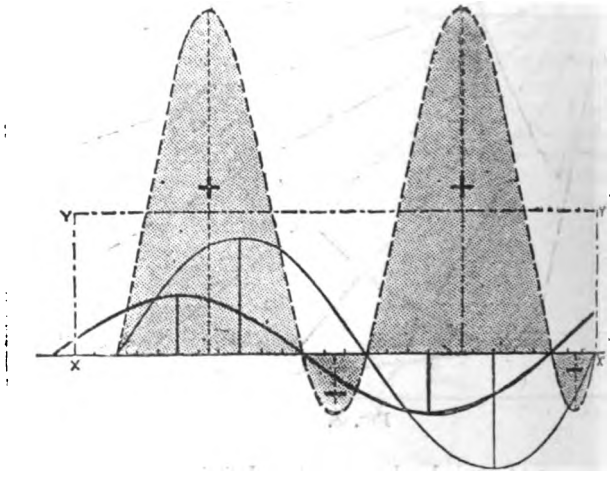

FIG. 11.

cuit of the dynamometer consist only of a few turns of wire, and let this movable circuit have joined in series with it a non-inductive resistance, which may be formed either of coils or wire, or incandescent lamps. Let this movable circuit with its added resistance be placed as a shunt across the ends of the circuit in which it is required to measure the power, being joined up, as shown in Fig. 12. Then when the alternating E.M.F. is applied to the circuit, the fixed coil of the dynamometer (now called a wattmeter) will be traversed by a periodic current identical with that passing through the inductive resistance. The movable coil of the wattmeter will be traversed by a current which will be in step as regards phase with the potential difference between the ends of the inductive circuit. When the dynamometer thus has its two circuits traversed by two currents, the force required to hold the movable circuit in its normal position against the electro-dynamic forces, is at any instant proportional to the product of these currents. If, then, the currents vary from instant to instant, and if the time of vibration of the movable coil is very long compared with the periodic time of the current, the mean value of the force required to hold the movable coil in its normal position with its axis at right angles to that of the fixed coil, will be proportional to the mean value of the product of the currents in the fixed and movable coils respectively, that is to say, will be proportional to the mean power being taken up in the inductive circuit. The force required to hold the movable coil in its normal position may be furnished by the torsion of a spring, and hence we can with such an instrument read off the mean-power being taken up in the inductive circuit, provided that the wattmeter is already standardised. The best way to standardise the wattmeter is to apply the wattmeter to measure the power taken up in a known standard non-inductive circuit, and, at the same

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time, to measure the mean-square value of the current flowing through this circuit and √mean-square value of the potential difference between its ends. In this way we apply the wattmeter to measure the known power being taken up in a non-inductive circuit, and we then obtain the constant of the instrument. The conditions of success in the use of this wattmeter are as follows:—

The current through the series coil of the instrument must have the same value as the current through the circuit to be measured, and the current through the shunt coil of the wattmeter must be exactly in step with the difference of potential between the ends of that shunt circuit; in other words, the shunt circuit must be strictly non-inductive. This can only be secured by winding the movable coil of the wattmeter with no very great number of turns.

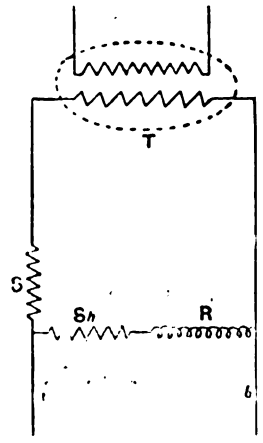

Fig. 12.

On the other hand, we then have to face another difficulty when we employ such a wattmeter to measure the power taken up in the primary circuit of transformers at high pressure. In this case, in order to obtain the sufficient magnetic moment in the movable circuit of the wattmeter, we are obliged to pass a relatively large current through the shunt circuit, and then we find that we are wasting a large amount of power in this shunt circuit. Unless this power is at disposal, it may prevent us from practically employing this method. But, fortunately, there exists another method of dealing with the matter.

In my first lecture I pointed out to you that when a transformer is being worked on open secondary circuit, or is very lightly loaded, the potential difference between the ends of the primary

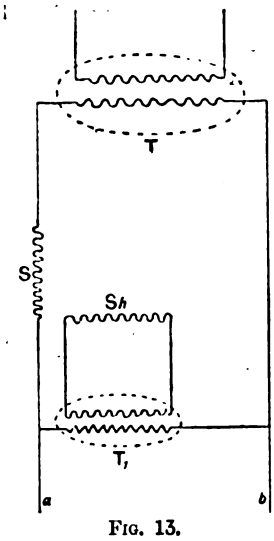

Fig. 13.

circuit is exactly opposite in phase to the secondary circuit of the transformer, of which the primary circuit is connected to the extremities of the circuit in which the power to be measured is taken up (*see* Fig. 13). We shall still have an arrangement in which the current in the shunt circuit of the wattmeter can be made to be in step with the potential difference between the ends of the inductive circuit, all other arrangements remaining the same, but in which the total power taken up in the wattmeter is very much less than in the former case.

To show the difference between these two methods, let us suppose that in the first place the wattmeter had a shunt resistance which could carry suitably one ampere, and that it is required to use the wattmeter to measure the power taken up in the primary circuit of the transformer at a pressure of 2,000 volts. We should then have to provide a non-inductive resistance capable of carrying 1 ampere at 2,000 volts, or nearly 2,000 watts expended on it. Under these circumstances, the power wasted in the shunt circuit of a wattmeter would be nearly 3 H.P. If, however, we do away with the non-inductive shunt resistance, and take a 1 H.P. transformer capable of transforming down from 2,000 to 100 volts, and put the shunt coil and the wattmeter together with a small additional resistance across the secondary terminals of this transformer, so arranging the resistance that still one ampere flows through the shunt circuit of the wattmeter, we then have the following power absorptions:—

The wattmeter shunt circuit will absorb 100 watts, and the transformer can be made to take as little as 60 or 70 watts, hence the whole arrangement, transformer, wattmeter, and additional resistance only takes up 150 watts instead of 2,000; in other words, a saving of 92½ per cent. It is clear, therefore, that the combination of the wattmeter with the transformer in this fashion is more economical than the use of a non-inductive external resistance. Generally, we may then say, that for the purpose of measuring alternating-current power, the best instrument to employ is the dynamometer wattmeter; using either one of the Siemens' form, in which the torsion of a spring is employed, or a balance form similar in construction to the ampere balance of Lord Kelvin. In those cases in which the potential differences between the ends of the circuit in which we wish to measure the power absorption does not exceed 100 volts the whole, the necessary resistances can be placed in the movable coil itself, winding it at a high resistance, so that we have as few turns as possible in that coil and yet obtain the necessary magnetic moment. We can then apply the wattmeter, standardised as above described, to measure the power taken up in any circuit inductive or non-inductive.

When we have to measure the power taken up by any inductive circuits, particularly when we are employing high pressures, as in measuring the power absorption in the primary circuit and transformers, the best method to adopt is to use a transformer in connection with the dynamometer wattmeter, as above described. The lecturer then proceeded to describe the engine-room wattmeter invented by Lord Kelvin, an illustrated description of which will be found in *The Electrician*, Vol. XXXI., p. 477.

(To be continued.)

CORRESPONDENCE.

OCEAN TELEPHONY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with much interest the report in *The Electrician* of Prof. Silvanus Thompson's lecture, entitled "Ocean Telephony," delivered before the Electrical Congress at Chicago.

The solution he offers of the problem of fast speed ocean telegraphy and telephony, and the suggestions he makes on the subject, are of special interest to cable engineers, and will no doubt direct their attention to methods by which the ideas of the professor may be submitted to practical test.

I would remark, however, that cable engineers have not been quite so indifferent to the subject as he supposes, and that some of them have given to it their serious attention for some time past.

One attractive feature of the proposed methods is that they can be carried out experimentally upon an "artificial line." Indeed, long before the Chicago lecture, I worked in almost exactly the same direction with a line equal to 1,000 miles of Atlantic cable, say, of 330 microfarads and 4,000 ohms. It is true that this apparatus possessed but a single conductor; but for many experiments this difference is not material.

The results obtained by the use of inductive shunts, placed either at the end or distributed at various parts of the line, showed so little advantage over old methods that neither was a patent applied for nor were the details of the experiments published.

One particular arrangement, represented by Fig. 7 (*The Electrician*, September 1st, page 473), was tried, using a transformer specially constructed and wound for the purpose. The results obtained with the syphon recorder were not unsatisfac-

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tory, but, as will be readily understood, successive impulses of one current followed by a reversal introduced troubles in the signals. These, unfortunately, were not overcome.

Of course, this special difficulty would not arise in telephony, where every current is followed by a reversal, but it is a very real one when the instruments and alphabet used in submarine telegraphy are employed.

There can be no doubt that Mr. Oliver Heaviside, F.R.S., may be regarded as the pioneer of the work in the direction of reducing the retardation caused in cables by electrostatic capacity by the employment in the circuit of electromagnetic induction.

As Prof. Perry says, in effect, when we can understand Mr. Heaviside we know he is right, but on one point of vital importance in submarine telegraphy he seems to hold opposite views to Prof. Thompson.

The latter, speaking of telephonic signals, says: "Never for such a purpose must a cable be constructed, as Atlantic cables have hitherto been, of a single conductor (of stranded copper), surrounded by an iron sheathing that comes in between the outgoing and the returning parts of the circuit, thus adding an enormous impedance." On the other hand, Mr. Heaviside says: "It seems very probable that the iron sheathing of a submarine cable may be beneficial, although it is not easy to precisely state its full effect." "Electrical Papers on the Self-Induction of Wires," Part. VIII.

Cannot Mr. Heaviside be persuaded to give his views on the methods proposed by Prof. Thompson? It is certain that the whole of the telegraph world would receive them with the greatest interest.—Yours, &c., ARTHUR DEARLOVE.

4, Great Winchester-street.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1893 Edition of "THE ELECTRICIAN" Electrical Trades' Directory and Handbook is NOW READY. This useful book contains over 1,000 pages, and several new and handy features have been added. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

TENDERS INVITED.—The Secretary of State for Foreign Affairs has learned from Her Majesty's Minister in Chili that the Municipality of Santiago have expressed a wish to receive tenders for the lighting of that city by electricity. Such particulars as are in the possession of Her Majesty's Government may be seen on personal application at the Commercial Department of the Foreign Office, between the hours of eleven and six daily.

———The Vestry of St. Pancras invite tenders for the extension of the buildings at their electric lighting station in Longford-street, N.W. Drawings can be seen at the offices of Prof. H. Robinson, C.E., 13, Victoria-street, S.W., from whom further particulars can be obtained. Tenders must sent in to Mr. T. Eccleston Gibb, vestry clerk, at the Vestry Hall, Pancras-road, N.W., by twelve o'clock noon on Thursday, the 21st inst. Further particulars are given in our advertisement columns.

TENDERS ACCEPTED.—The Electric Lighting Committee of the Lancaster Corporation have accepted the tender of Messrs. Manlove, Alliott and Co. for the supply and erection of wrought-iron roofs for the engine and boiler house; and that of Mr. C. Dennis, of Bury, for the erection of a brick chimney, at the Electricity Works, Marton-street.

APPOINTMENTS.—Mr. Frederick Siemens, of 10, Queen Anne's-gate, Westminster, announces that he has appointed Mr. Emil Biedermann and Mr. Ernest William Harvey to succeed the late Mr. John Head as managers of his civil engineering business for this country, France, Belgium, Spain, Portugal, and America. These gentlemen have for many years been engaged as engineers on Mr. Siemens' technical staff.

SALES BY AUCTION.—Messrs. Furber, Price and Furber will hold a peremptory sale under a Judge's order, of the plant, machinery and instruments of the London College of Electr cal Engineering on the premises, 9 and 10, Railway-approach, and 3, 5 and 7, Denman-street, London Bridge, S.E., on Tuesday, the 19th instant, and following day, at 12 for 1 o'clock. The plant includes a considerable variety of machinery, lathes, tools, engines, &c., particulars of which will be found in our advertising columns.———Our readers are reminded that the sale by auction by Messrs. Wheatley Kirk, Price and Goulty, of the valuable and modern plant, machinery, &c., *in re* Blakey, Emmott and Co., takes place place at the Northern Telegraph Works, Square-road, Halifax, Yorkshire, on Tuesday, Wednesday, Thursday, and Friday next.

LIQUIDATIONS.—The shareholders of the Trent Gas Engine Company (Limited), of New Basford, resolved, at a meeting held on the 23rd ult., to wind up the Company voluntarily, and Mr. Robert Mellors, accountant, of Nottingham, was appointed liquidator.

——— By resolution passed on August 10th, and confirmed on August 31st, the shareholders of the United Telephone Company of Rosario (Limited) have decided to wind up the Company voluntarily, and Mr. T. S. Hamilton, the secretary, has been appointed liquidator.

BANKRUPTCY.—The public examination took place at the Leeds Bankruptcy Court on Tuesday of Harry Austin and James Myers, trading as Austin and Myers, manufacturing electricians and electrical engineers, Armley, Leeds. The liabilities were £261. 18s. 11d., and the assets £79. 4s. 6d., the debtors attributing their failure to "losses by bad debts and expenses of advertising." It was stated that at a private meeting of creditors an offer of 5s. in the £ was made, but it was not accepted, and the petition was accordingly filed. The examination was closed.

SHOP LIGHTING.—The last issue of the *Warehouseman and Draper* contains an article contrasting the electric light with gas for shop lighting, in the course of which it remarks that, with respect to efficiency, economy, health, and safety, there can be no doubt that, "in at least three out of the four points, the electric light is far and away superior to gas."

TRADE JOURNALISM.—The publishers of the *Paper Maker* have just issued what they term "a special World's number" of that journal, containing specially-written articles on the subjects of paper making and paper-making machinery. The number is admirably got up, and any of our readers taking an interest in the subject will find much to instruct them in this special issue, which is price 2s.

THEATROPHONES.—The National Telephone Company have fixed a set of theatrophones by which the entertainment at the Empire Music Hall, Cardiff, can be heard at the Panopticon in that town, and at the recently opened exhibition at Bristol.

THE CONTRACT FOR STORAGE BATTERIES FOR ST. PANCRAS.—We understand that the above contract was not, as its title would indicate, entirely for storage batteries, the greater portion being for instruments, cables, and motor transformers. As is well known throughout the trade, the Electrical Power Storage Company confines its business entirely to the manufacture of storage batteries and the more immediate accessories therefor; they were accordingly not able to tender directly on the terms of the specification. Would it not be as well for electrical engineers when drawing up specifications to bear in mind that some portions of the plant may be of such special character as to necessitate the subdivision of the contract. There is scarcely a single firm in the country which can supply all the above collection of apparatus from its own shops. Both cable making and storage batteries are essentially special articles of manufacture.

MESSRS. RICHARD HORNSBY AND SONS (LIMITED).—This firm have commenced to make water-tube boilers under the patents of the Mills Patent Sectional Boiler Company, and will in future carry on the manufacture of these boilers under the title of the "Hornsby" Water-Tube Boilers, which are made with patent water-lined furnaces (single and double flues) for bituminous and smoky coal, and with large brick-lined furnaces for inferior and bulky fuel, or for any fuel requiring large grate area. As the boilers can be handled in sections where transport is difficult, they are specially adapted for export. Messrs. Hornsby have put down for the Manchester Corporation, at their central electric lighting station, six vertical compound tandem condensing steam engines, which, we learn, are giving every satisfaction. The firm have lately been busy supplying a large number of engines for electric lighting purposes in various parts of the world.

WATERHOUSE ELECTRICAL MANUFACTURING COMPANY (LIMITED). This Company have completed, and are prepared to supply, a new alternating arc lamp, which, we are informed, at a recent test on a tension of 60 volts, gave excellent results. The Company are

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issuing a price list and a description of the Waterhouse arc lamp, giving full illustrated details. This list is of a handy pocket size, and can be obtained on application at the Company's works, 67, Southwark Bridge-road, S.E., or at the offices, 33, Old Broad-street, E.C.

TELEGRAPHIC ADDRESSES.—Mr. H. Sell, of Fleet-street, London, E.C., announces that he has obtained the permission of the Postal authorities to publish a complete official list of registered telegraphic addresses. This Directory is, we understand, to be published annually, with quarterly supplements.

THE "ENGINEERING MAGAZINE."—The September number of the *Engineering Magazine* contains articles on "Some Facts about the Silver Industry," by Albert Williams, jun.; "A Scientific Analysis of Money," by Emil Schalk, C.E.; "Steamboating in the West and South," by Walker Kennedy; "Growth of Commerce on the Lakes," by H. C. Pearson; "The Need of Uniform Building Laws," by Wm. J. Fryer; "Nickel-Steel Armour-Plate for the Navy," by R. B. Dashiell, U.S.N.; "Electricity and Electric Generators," by Horace F. Parshall; "Distance and Railway Tariffs," by James L. Cowles; and the usual Editorial Departments. Many of the articles are accompanied by high-class illustrations of the character familiar to readers of the magazine.

BELFAST.—At the last meeting of the City Council Mr. Barklie complained that they were without information regarding the progress of the electric light works, and he would like to know if these works had been abandoned. Mr. Young, in reply, said that some premises recommended by Prof. Kennedy had been taken for the purposes of the electric lighting station, and there was only a question in regard to title to be settled.

BLACKPOOL.—The current from the new central station in Princess-street was turned on for the first time on Thursday last week to some private consumers, and it is expected that in the course of the next few days the entire installation of public and private lighting will be completed and at work. The electric tramways are at present worked from a separate installation in Princess-street, but it is now proposed to produce the current for both tramway and illuminating purposes at the one central station, and it is probable, therefore, that within a short time two more engines and dynamos will be put down at the new works.

BOURNEMOUTH AND POOLE.—An exhibition has just been opened at Bournemouth in which an installation of electric cooking, &c., is on view, under the superintendence of Mr. E. R. Dale, who has also charge of a similar installation at an exhibition to be opened at Poole (Dorset).

BRIGHTON.—The masonic rooms at the Pavilion are in future to be lighted by electricity.

CAPE TOWN.—It will be remembered that the Town Council in November last accepted the tender of Messrs. Siemens and Halske for a system of electric lighting for the city. The installation is to be completed by the end of 1894, and we learn from Cape journals just to hand that the construction of the necessary buildings had been commenced.

CLERKENWELL.—The Vestry, on Thursday, refused to accede to a request from Mr. Sydney Morse that they consent to an extension of time till the beginning of next year for carrying out the County of London Electric Lighting Provisional Order.

DUNDEE.—The Lighting Committee of the Police Commission are about to hold a special meeting to consider the advisability of increasing the number of public thoroughfares to be lighted by electricity. Some 40 additional lamps would be required, entailing a cost of about £800 for their erection and maintenance.

FALMOUTH.—The Urban Sanitary Authority at their last meeting directed the Lighting Committee to obtain a report as to the probable cost of lighting the main streets by electricity.

HOLBORN.—At the conclusion of the business at the meeting of the Holborn Board of Works at the Town Hall on Monday, the Chairman (Mr. Phillips) at the request of the members switched on the electric light, which has been installed at a cost of over £400, to the large hall and committee room. The light was both clear and brilliant, and all admitted it to be a great improvement on the old illumination by gas. Messrs. Verity and Sons, of Covent-garden, were the contractors for the work, which was carried out under the supervision of Mr. John Dyer, the firm's foreman.

HULL.—In connection with the extension of the electric lighting scheme outside the old town, the current was turned on to consumers for the first time last week.

KENDAL.—A motion had been placed on the agenda paper for consideration at the meeting of the Town Council last week, that a committee be appointed to consider the expediency of the Corporation applying for a Provisional Order empowering them to supply the electric light within the Borough, but the matter was deferred until the next meeting.

KINGSTON-ON-THAMES.—As far as the bricks and mortar are concerned, the construction of the central station may be considered as practically finished. The two large boilers, which have been supplied by Messrs. G. E. Belliss and Co. (Limited), have been fixed, and the machinery in being rapidly placed in position.

LAMBETH.—The Board of Guardians had before them at their meeting last week the report, prepared by Mr. W. H. Preece, upon the proposal to light the Workhouse and Infirmary by electricity. After noting that the cost of gas for lighting purposes now amounted to about £1,500 per annum, Mr. Preece stated that, in his opinion, some 1,750 incandescent lamps of 16 c.p., or their equivalent, would be necessary to properly light the two buildings under consideration. To provide this light plant would be required, costing, in the first place, £6,900, and the working expenses and interest on capital would amount to about £1,850 per annum. Against the slightly increased cost must be put the value of the better lighting in the Infirmary, where the purer atmosphere would do much to aid the medical staff. After some discussion, the consideration of the matter was adjourned for a month in order that some further particulars might be obtained from Mr. Preece.

LYNTON.—At the last meeting of the Local Board it was stated that an iron framework had been fixed on the Rhine Tower at Lynmouth for a 2,000-c.p. arc light. Exception was taken to the appearance of the structure, and after discussion it was resolved that the Lighting Committee should arrange for a smaller light at the corner of the tower, and that the Trinity Brethren be informed that the proposed 2,000-c.p. light would not be installed.

MONMOUTH.—At a meeting of the Town Council on Monday a committee of five was appointed to inquire into the question of the purification of the river, and to endeavour to ascertain if sufficient water-power could be obtained for generating electricity for municipal purposes. A sum of £10 was voted for the purpose of obtaining the opinion of an electrical expert.

MORLEY.—At a meeting of the Town Council on Monday it was resolved, on the recommendation of the Electric Lighting Committee, to advertise for schemes to be submitted for the electric lighting of the Town Hall and the borough generally; the competitors to show in detail two schemes, one for the lighting of the Town Hall alone, and the other for the lighting of such parts of the borough as they might think could be profitably supplied with the electric light.

NEW ROMSEY.—There is an opportunity to introduce the electric light into New Romsey, where the Gas Company, owing to a dispute with the Corporation, have taken the gas lamps away. The Council have recently received tenders for lighting the town with oil, but would probably be open to a reasonable offer for the electric light.

PERTH.—The Town Council, at their meeting on Monday, refused to give their consent to an application by the Caledonian Electric Supply Company (Limited) to the Board of Trade for a Provisional Order authorising them to supply electric light to the burgh of Perth.

WORCESTER.—At the last meeting of the Board of Guardians it was moved that the resolution recently passed by the Board, adopting gas as the illuminant for the new workhouse, should be rescinded, and that electricity should be adopted instead. It was pointed out that as the Corporation had resolved to adopt electricity for the lighting of the city, it was the duty of the Guardians, in the interests of the ratepayers, to have the light which was supplied by the Corporation. The motion was, however, lost by a small majority.

WREXHAM.—At the last meeting of the Town Council a letter was read from the Board of Trade informing them that the proposed revocation of the Wrexham Electric Light and Power Order, 1890, had been postponed for one year from August 14th. A letter was read from Messrs. Lewis and Son, solicitors, stating that the Wrexham Electric Light and Power Company (Limited) were prepared, in accordance with the offer made by the Chairman of the Company to the Lighting Committee on April 25th, to sell the Company's Provisional Order for £500, and it was decided to call a special meeting of the Council in Committee to consider the question.

BOOKS RECEIVED.

"Notes et Formules d'Électricité Industrie." By Bouquet. (Paris: E. Bernard et Cie. 1893).

"Engineering Materials." By Edward C. R. Marks. (Manchester: The Technical Publishing Company, Limited.) Price 1s. 6d. net.

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PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

August 28, 1893.

16,168. W. J. DAVEY. London. Improvements in arc electric lamps.

16,175. A. P. LUNDBERG. London. Improved method of fixing metal parts of electrical fittings to porcelain or other refractory substances.

16,197. P. SCHOOP. London. Improvements in electric traction apparatus.

16,205. A. CHESTER and J. J. RATHBONE. London. A novel construction or arrangement of electrical resistance coil, and in appliances therewith for determining the amount of current passing through said coil.

August 29, 1893.

16,226. E. EGGER, F. A. WESSEL, and H. NAUMBURG. Manchester. Improvements in electric cars.*

16,230. W. B. RAMSEY. Grimsby. An electric door mat for shop entrances and the like.

16,265. G. PHILIPPART and G. LENTZ. London. Improvements in electrodes for secondary voltaic batteries.

August 30, 1893.

16,307. J. SWINBURNE. Teddington. Improvements in electric meters dynamos, electrolysis of solutions, manufacture of sodium and sodium substitutes, manufacture of potassium cyanide, gold extraction, and recovery of tin from scrap.

16,342. G. WILKINSON. Southport. Improvement in conductors and arrangement thereof for distribution of electrical energy.

August 31, 1893.

16,389. J. F. MCELROY. Manchester. Improvements in electric heating apparatus.*

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

14,567. HINDLEY. Cases for electric cables.

16,154. MILLS. Inking apparatus for telegraphy.

16,570. ELMORE. Electrical propulsion of vehicles.

16,866. MÜLLER. Secondary batteries.

17,287. HAMER. Electric gas lighting apparatus.

17,501. LOCH. Electric switch.

17,855. TOMLINSON. Electrical distribution.

18,037. Mountain Electric Welding Apparatus.

18,166. LAKE (Noriega). Microphones.

18,359. DAVIS. Electric regulators.

18,878. TAYLOR and TUNNICLIFF. Electrical switches, &c.

22,923. DE FERRANTI. Electric cables.

1893.

13,279. SEIFFERT. Telephones.

13,408. MASON and VAN DERWERKEN. Electric batteries.

COMPANIES' MEETINGS AND REPORTS.

Direct Spanish Telegraph Company (Limited).

The fortieth ordinary general meeting of this Company was held at the offices of the Company, 280, Winchester House, Old Broad-street, London, E.C., on Friday, September 1, 1893, for the purpose of receiving the Directors' report and accounts, and for transacting the ordinary business of the Company; and notice was also given that immediately after the conclusion of the ordinary meeting an extraordinary general meeting of the Company would be held at the same place to supply the casual vacancy in the office of auditor, occasioned by the death of Mr. Herbert R. Duke. Sir John Pender, G.C.M.G., M.P. (Chairman of the Company), presided.

Mr. CH. GERHARDI (the Manager) read the notice calling the meeting and the minutes of the last meeting, which were confirmed and signed by the Chairman as a correct record.

The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, you have had the report in your hands for some time, and I presume you will agree to take it as read. A reference is made in the report to the death of Sir James Anderson (the late Chairman of this Company) in paragraph 5, which states:—"The Directors report with extreme regret the death of Sir James Anderson, who had been Chairman of the Board since 1884. At the invitation of the Directors, Sir John Pender, G.C.M.G., M.P., has joined the Board to fill up the vacancy." If you will allow me, I will refer to that first. Sir James Anderson, as you are aware, was the Managing Director of the Eastern Telegraph Company. He was a well-trusted and very efficient colleague in that Company, and when this Company became more related with the Eastern Telegraph Company, and with its wide and extensive system—the Eastern Company being one of the largest shareholders in this Company—it was suggested by myself that Sir James Anderson and my son should join the Board of the Company, and they did; and the result has been, I think, on the whole very successful for this Company. Now, in expressing regret at the loss of Sir James Anderson as a colleague and a friend, I am only saying that which I feel very deeply and very warmly. For 25 years we were more or less associated with the development of submarine telegraphy, and from his great nautical experience he was of value in every way, and I feel that he having passed away—and death has been rather strong upon us during the last six months, we having lost also our auditor—I feel that looking to the close relationship which existed betwixt the Eastern Company and this Company, that I being asked to take Sir James Anderson's place that the experience which we had gained together might be valuable it made available here, and therefore while deploring the loss of Sir James Anderson, and expressing regret at the death of a valued friend and colleague, I have also to thank the other gentlemen for the confidence they have placed in me in asking me to take the position which Sir James Anderson formerly held here. I did not take the position from love of more work, but from a desire to keep the great system of submarine telegraphy which has been more or less developed as one of the great works of the last 25 years—a work which probably has had more effect upon the political and commercial system of the world than anything else that has been done. I say my grave desire was to keep that system—I, and my colleagues—in a sound state, and to do everything in my power to carry on the great development of it during the next 25 years, although probably I shall not be present at the expiration of that time, but at all events I shall try to do as good work in the future as has been done in the past. And now, if you please, we will come to the general business of the day. You will see from the figures of the report, which you have before you, that the annexed accounts for the half-year ended June 30, 1893, show, after providing for debenture interest, a balance to the credit of profit and loss of £4,645. 13s. 9d. The traffic receipts show a decrease of £593. 8s. 9d. as compared with the corresponding period of 1892. The falling off in the receipts is chiefly due to the stagnation of Stock Exchange business in England, Spain, and France. It is not necessary for me to tell you that probably never in my recollection has there been a period of such intense depression of trade as has existed during the last six months, which we are now referring to, and I believe that those results which are somehow brought about by overtrading bring about eventually a more wholesome state of things, and I only hope that that will be the case in this instance. As you all know, telegraphy—submarine telegraphy—in every part of the world is now used in bad times as well as in good. It is a remarkable feature in submarine telegraphy during the last six months that when things were probably at their worst, submarine telegraph stocks, instead of going back went rather a little better. I feel that the development of submarine telegraphy can only be looked for through the development of commerce throughout the world. The working expenses are £130. 6s. 5d. in excess of those for the corresponding period of last year, and the increase in the working expenses is quite unavoidable, and is principally in the item of salaries and general expenses which cannot be regulated according to the number of telegrams conveyed. Stationery, on the other hand, which is used in proportion to the number of messages, shows a decrease. There is no falling off; in fact there is a slight increase in the traffic derived from other sources, viz., commercial and industrial. Every effort is being made to reduce expenditure, but it must be remembered that we cannot with safety make any serious reduction in our staff, as any sudden influx of business could not be efficiently met, some time being required to train operators for our particular work, and, as it will be seen by the accounts, the item of salaries and wages is the principal one in our expenses. Our working expenses will, however, compare favourably with those of other cable companies. I dare say that you will understand that when young men come to us they come at moderate salaries, and they meet with that interest and encouragement that every young man looks for when putting his foot upon the first rung of the ladder of life. Still, this is after all a comparatively small matter, and I think on the whole you will consider it satisfactory. The Company's cables and the land lines in connection with them have continued in good working order throughout the half-year. The other day, however, we had a breakdown, and that will be alluded to at the next meeting. I think I may say that that breakdown was probably one of the most rapid and prompt repairs ever made in connection with submarine telegraphy, as the ship left, mended the cable, and was back at London inside a week. After adding the usual sum of £2,500 to the reserve fund, the balance of profit and loss amounts to £2,145. 13s. 9d. To this the Directors propose to add £345. 0s. 10d. from interest on investments, and recommend the payment of the dividend at the rate of 10 per cent. per annum on the Preference shares, and a dividend at the rate of 4 per cent. per annum (free of income-tax) on the Ordinary shares. The reserve fund will then amount to £35,963. 11s. 3d. The rate of dividend on the Ordinary shares is the same as has been paid since July, 1891. The dividend warrants will be as usual issued on the October 2nd, the 1st being Sunday. Out of the reserve fund as it now stands, namely, £35,963. 11s. 3d., no less than £32,279. 18s. 5d.

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are invested, yielding an average interest of nearly 3½ per cent. In the conduct of submarine telegraphy I find the bigger the reserve fund the more satisfactory it is to the shareholders generally. If we acted on the principle of dividing every shilling of the profits we had to divide amongst the shareholders the Company would not be anything like so valuable as it is to-day. A good efficient reserve fund is in my opinion the basis of success in submarine telegraphy. The traffic since July 1st last up to date is £275 short of that for the same period of 1892. This is still partly owing to the absence of Bourse traffic. As you know, that traffic has a wonderful effect upon our returns, and if any of the gentlemen I am addressing now know anything of the Stock Exchange they will know that it has not been particularly lively or particularly profitable during the past six months; and as far as that department of our business goes we have, more or less, suffered. At the same time, however, it is comparatively a small sum, and I hope the dark times are passing away, and they will be replaced by brighter ones. We have now had a considerable period of depression, and I hope it has brought about a purification of the commercial atmosphere, and we shall now have a brighter and more prosperous time in trade, and if we have that you may depend that submarine telegraphy will follow. I will now move—

"*That the report and accounts now submitted be and the same are hereby received and adopted.*"

Mr. E. ETLINGER: I beg to second that.

There being no questions, the resolution was put and carried unanimously.

The CHAIRMAN then moved, and Mr. JOHN D. PENDER seconded—

"*That the dividend at the rate of 10 per cent. per annum (less income-tax) on the Preference shares, and a dividend at the rate of 4 per cent. per annum (free of income-tax), on the Ordinary shares, both for the half-year ended June 30, 1893, be and are hereby declared.*"

The motion was carried.

The CHAIRMAN: That is the business, gentlemen, of the ordinary meeting. The extraordinary meeting will now be held. Will any shareholder be kind enough to move this resolution, as it is one for election of the Auditor, and should come from that side of the table.

Mr. W. HIBBERDINE: I have much pleasure in moving—

"*That Messrs. Deloitte, Dever, Griffiths and Co. be and are hereby elected auditors to the Company for the current year with a fee of 30 guineas, in the place of Mr. Herbert R. Duke, deceased.*"

Mr. WEST seconded the resolution, which was agreed to without discussion.

The CHAIRMAN: The firm of Messrs. Deloitte, Dever, Griffiths and Co. is a firm of accountants well known in London, and they are responsible to you for the accounts which they pass. They are appointed by you, and, as far as we can say, having known them for a number of years, they know a great deal about their business, and I can say myself that they are fully entitled to the confidence you have placed in them.

Mr. WEST: I should like to propose a vote of thanks to the Chairman and Directors for the great trouble and anxiety they have experienced during these troublous times, and for looking after the business of the Company in the manner in which they have. I have known Sir John Pender for a great many years, and have always attended these meetings, and I may say that I always feel safe when I have a little money in telegraph shares.

Mr. CREASEY seconded the resolution, which was agreed to.

The CHAIRMAN: Gentlemen, I thank you on behalf of my colleagues and myself for the vote which you have passed. The work that has been done in looking after this telegraph system has sometimes been of a very complicated nature, and has required very prompt attention. There is, however, something of the *esprit de corps* in this Company which helps us to feel that we have a great interest to represent and a great position to maintain; and it is our duty and pleasure to strengthen that position every way by every means in our power. I thank you for the compliment which you have done us.

The proceedings then terminated.

NEW COMPANIES, STATUTORY RETURNS, &c.

[In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1893, pages 320-348, &c., &c.]

DOLGOROUKY COPPER MINES AND SMELTING COMPANY (LIMITED).—This Company has been registered with a capital of £210,000, in £1 shares, to carry on business as copper miners and smelters, mechanical and electrical engineers, machinists, wire drawers, tube makers, metallurgists, &c.

BRITISH VOLTA ELECTRIC GLOW-LAMP COMPANY (LIMITED).—This Company was registered on August 31st, with a capital of £2,000, in £1 shares, to manufacture, sell, and deal in incandescent electric lamps, and telegraphic, telephonic, and electric apparatus and appliances generally, to construct, lay down, fix, carry out, establish, work, manage, control, regulate, and deal in all necessary works, cables, wires, accumulators, lamps, apparatus, appliances, and conveniences for the transmission and facilitation of telegraphic and telephonic communications and messages, and for the lighting of towns, streets, building and places (public and private), and generally to carry on the business of supplying electricity. The subscribers are:—

	Shares.
A. T. Turney, Berghill-road, Sydenham, electrical engineer ...	1
G. White, Great Missenden, Bucks	1
E. C. Lacey, 121, Knight's-hill, West Norwood	1
G. Willard, 47, Forest-lane, Stratford, E., electrician	1
W. Habgood, 49, Queen Victoria-street, E.C., electrical engineer	1
H. Foster, 87, Grange-road, Bermondsey	1
W. C. Stembridge, Iliffe-street, Kennington Park-road, S.E....	1

RAILWAY ELECTRICAL FOG SIGNAL SYNDICATE (LIMITED).—The statutory return of this Company, made up to March 26, 1892, was not filed until July 19, 1893, when out of a nominal capital of £25,000, in £1 shares, 18,000 had been taken up, all of which were issued as fully paid in consideration for the patents and business acquired by the Company. The 1893 return was filed last March.

READING ELECTRIC SUPPLY COMPANY (LIMITED).—No business has yet been done by this Company, as is seen by the last return filed on August 31, 1893, which shows that the seven signatories' shares are the only ones taken up out of a nominal capital of £75,000, in £5 shares.

SAXBY AND FARMER (LIMITED).—The statutory return of this Company, made up to August 28th, has been filed. The nominal capital is £25,000, in £10 shares, of which 2,021 have been taken up, 1,800 have been issued as fully paid, and the full amount has been called and paid on the remaining 221 shares.

SHROPSHIRE ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The first annual return of this Company, made up to June 14, 1892, was filed on August 1, 1893. The nominal capital is £25,100, divided into 2,500 Ordinary shares of £10 each, and 100 Founders' shares of £1 each. 275 Ordinary and 44 Founders' shares have been taken up, and a call of 5s. per share called on the former class, while no calls have yet been made on the £1 shares. The shareholders have paid on allotment £595. 5s., leaving £22. 10s. due. The third annual return, made up to June 14, 1893, and also filed on August 1st, shows no alteration in the above figures.

VEALE AND CO. (LIMITED).—An agreement, dated May 17, 1893 (filed June 16th following) between John E. Veale, of St. Austell, Cornwall, electrical engineer (referred to as the vendor), of the one part, and the above-named Company, of the other part, provides for the sale to the Company of the business of electrical engineer carried on by the vendor at St. Austell, Cornwall, and the transfer of the electric lighting undertaking for the Local Board district of the parish of St. Austell for £3,939. 18s. 6d. The vendor has advanced certain sums of money to the Company, amounting in all to £805. 12s. 10d., and the whole (including the purchase consideration) will be fully satisfied by the allotment of 4,644 fully-paid shares, Nos. 4,905 to 9,548 inclusive.

CITY NOTES, &c.

AN AMERICAN ELECTRIC RAILROAD IN DIFFICULTIES.—The Sandusky, Milan, and Huron Electric Railroad has been placed in the hands of J. C. Gilchrist, of Vermilion, as receiver. The road is one of the largest electric lines in the country. The failure of Cleveland capitalists to take $75,000 of the Company's bonds, as promised, embarrassed it to such an extent that it could not meet the demands of creditors, and the receivership is the result.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended September 3rd were £745, as against £737 for the corresponding period of last year, being an increase of £8. The total receipts for the half-year amount to £7,373, against £6,927 in the corresponding period of 1892, being an increase of £446.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of August are £3,000, as compared with £3,166 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY.—The gross receipts for the month of August were £1,670, as compared with £1,884 for the corresponding period of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce the opening of a branch office at Winchester House, Old Broad-Street, E.C. for the acceptance of telegrams for South America, South Africa, Egypt, India, China, Australasia, &c.——The Company also notifies that the Brazilian Government having suspended their International telegraph service, messages for that country cannot at present be accepted. Telegrams for Uruguay, Argentina, &c., can be accepted as usual.——The traffic receipts for the month of August amounted to £51,991, and to £49,069, in the corresponding period of 1892, an increase of £2,922.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of the Eastern Extension, Australasia and China Telegraph Company (Limited) for the month of August, 1893, amounted to £41,791 and to £42,035 in the corresponding period of 1892; decrease, £244.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this Company for August amounted to £23,200, and from January 1st to August 31st to £180,000. In the corresponding months of 1891 and 1892 the amounts were £189,400 and £175,600 respectively.

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WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED.)—The receipts of this Company for the two weeks ended August 31st were £1,732, as compared with £1,938 for the corresponding period of last year.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended September 1, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,725.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price. Aug. 30.	Price Wednesday, Sept. 6.	Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business Done During Week Ending Sept. 6. Highest	Lowest
			TELEGRAPHS						
£1,134,640	Stock	12/6	Anglo-American	49½ 50½	50½ 51½	5 6 10	Jan. Apr., July, Oct.	50½	..
£2,932,680	Stock	25/0	Do. Preferred	92 93	92½ 93½	5 17 8	" .. "	93½	92½
£2,932,680	Stock	5/0	Do. Deferred	9½ 10	9⅝ 10⅛	..	" "	10⅛	9⅞
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	99 102	99 102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	11⅞ 12⅛	11⅞ 12⅛	5 6 1	Mar., June, Oct., Dec.	12⅛	11⅝
£36,400	£100	5%	Do. 5 per Cent. Bonds	99 103	99 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1901)	107 111	107 111	4 10 1	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	120 130	127 132	5 6 1	April and October..	132	..
16,000	10	8/0	Cuba Submarine xd	11½ 12½	11 12	6 13 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent. xd	18½ 19½	18 19	5 5 3	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½ 3½	2½ 3½	4 11 5	April and October..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	8½ 9½	8½ 9½	5 5 3	" "	..	..
60,710	20	8/6	Direct United States	11⅜ 11⅝	11½ 11⅝	5 19 2	Jan., Apr., July, Oct.	11⅝	11
400,000	10	5/6	Eastern	14⅜ 15⅛	15 15½	4 5 3	" "	15½	15
70,000	10	6%	Do. 6 per Cent. Preference	16 16½	16 16½	3 12 9	" "	..	..
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	111 114	111 114	3 10 2	May and November	112½	111
£105,900	100	5%	Do 5 per Cent. Debentures, 1899	105 109	106 109	4 11 9	February & August	109	..
250,000	10	2/6	Eastern Extension	15 15½	15½ 15¾	4 11 1	Jan., Apr., July, Oct.	15¾	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	110 113	110 113	3 10 10	February & August	111½	..
£70 600	100	5%	Do. 5 p. c.(Austin. Gov. Sub.) Debs 1900	102 105	102 105	4 15 3	January and July ..	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb.,1900	100 103	100 103	4 17 1	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	100 103	100 103	3 17 8	February & August	101½	10
£200,000	£25	..	Do. 4% Mauritius Sub Debs.	102 105	102 105	..	May and November	..	..
180,227	10	4/0	Globe Telegraph and Trust	9⅜ 9⅞	9⅜ 9⅞	4 13 8	Jan., Apr., July, Oct.	10	9⅜
180,042	10	6%	Do. 6 per Cent. Preference	15 15½	15½ 16⅜	3 18 1	" "	15½	1
180,000	10	5/0	Great Northern	19⅜ 20½	19⅜ 20⅛	4 4 2	Jan., April, and July	20⅛	2
£: 0,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue .. xd	106 108	103 106	4 14 4	March & September	..	..
17.000	25	37/6	Indo-European	39 42	39 42	5 19 1	May and November	39½	..
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	3 6 8	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures xd	107 110	104 107	5 12 2	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs.	100 103	100 103	3 17 8	..	..	..
11,802	8	4/0	Reuter's	4½ 5½	4½ 5½	..	April and October..	5	4⅞
2,381	£100 Cert.	30/0	Submarine Cables Trust 6 per Cent.	115 120	115 120	5 0 0	" "	..	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July ..	..	..
£260,900	100	5%	Do. 5 per Cent. Debentures xd	99 102	97 100	5 0 0	March & September	99	..
30,000	10	2/0	West Coast of America	2 3	2 3	..	January and July ..	..	..
£150,000	100	3%	Do. 3 per Cent. Debentures, 1902	97 101	97 101	7 18 5	June and December	..	..
88,321	10	6d.	West India and Panama	1 1⅛	1⅛ 1⅜	..	..	1⅛	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 10⅝	10½ 10⅝	5 11 7	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	105 108	106 109	4 11 9	June and December	108½	..
64,242	15	4/6	Western and Brazilian	6½ 6⅝	6½ 7	5 7 6	May and November	6⅝	..
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5⅝ 6½	5⅝ 6½	..	..	6½	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1½ 1⅝	1½ 1⅝	..	..	..	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	..	..
£232,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
£1,214,000	£1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120 125	120 125	5 12 0	May and November	..	..
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds xd	101 104	100 103	5 16 6	March & September	10	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	2 3	2 3	..	..	..	..
22,500	10/0	3½d.	Consolidated Telephone Const. & Maintenance	1/16 1/16	1/16 1/16	..	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid) xd	1/16 1/16	1/16 1/16	7 18 2	Yearly	..	..
458,867	5	2/6	National	4⅜ 4⅝	4⅜ 4⅝	5 8 1	June and December	4⅝	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14½ 15½	14½ 15½	3 17 5	" "	15 1/16	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14 15	14 15	4 0 0	" "	..	..
90,950	5	2/0	Do. 5% Non-Cumulative 3rd Pref.	5½ 5⅝	5½ 5⅝	4 10 11	.. ..	5 1/16	5 1/16
726 477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	111 113	111 113	3 19 8	January and July ..	112⅛	112
56,000	5	1/0	United River Plate	2 2½	2 2½	..	January and July ..	..	..
£146.370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	11 11½	11 11½	..	..	11⅜	..
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½ 13	12½ 13	..	..	1/16	..
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	.. ..	.. ..	..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
8,322	£5	..	House to House Electric	.. ..	.. ..	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	.. ..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July ..	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4 1/16 4 1/16	4½ 4½	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6½ 6⅝	6 6½	..	..	..	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	5⅝ 6½	6½ 6⅝	2 19 3	..	6½	6⅜
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102 105	102 105	4 15 3	June and December	105	104
6,452	£10	..	Notting Hill Electric	5 6	5 6	..	..	..	..
19,980	£5	9½%	St. James' and Pall Mall	6½ 6⅞	6½ 6⅝	..	..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	7⅞ 8½	8 8½	4 2 4	..	8 1/16	..
59,900	5	1/6	Westminster Electric Supply (fully paid)	5 5½	4⅞ 5⅛	3 6 8	..	5	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	2/1	Brush Electrical Engineering xd	3 3½	3⅛ 3¼	..	..	3 1/16	..
75,000	2	6%	Do. 6 per Cent. Preference xd	2 2½	2 2½	5 6 8	..	2½	2 1/16
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures xd	107 109	105 107	4 4 1	March & September	106½	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	4 5	4 5	..	January and July ..	..	..
12,139	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	.. ..	..	..	..	..
49,900	10	12/0	Electric Construction	1½ 1⅝	1½ 1⅝	..	..	1⅝	..
91,195	2	10/0	Elmore's Patent Copper Depositing	½ ½	⅜ ⅝	..	..	⅝	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22¼	22
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	1½ 2½	1 2	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/0 4/0	3/0 4/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	1½ 2½	1½ 2½	15 11 8	May and November	2⅜	2
37,350	12	12/0	Telegraph Construction and Maintenance	32 34	32 34	5 5 10	March and July....	33	..
£150,000	100	5%	Do. 5 per Cent. Bonds, red.1894	101 104	101 104	4 16 2	January and July ..	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	¾%	City and South London Railway	35 37	35 37	1 13 9	May and November	36½	..
37,500	£10	..	Liverpool Overhead Railway	5½ 5⅝	5½ 5⅝	..	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 800.—Vol. XXXI. FRIDAY, SEPTEMBER 15, 1893. PRICE FOURPENCE. *Annual Subscription (U.K.), 19/6*

NOTES.

The Presidential Address delivered before Section A of the ritish Association yesterday by Mr. Glazebrook dealt for e most part with the history of the undulatory theory of ght. Little did Hooke, Newton, Huygens, Fresnel, and en Cauchy, think that in studying the phenomena of optics, nd in building up a theory of light, they were laying the undations for a far wider theory—the theory of the ether—medium for the transmission, not only of light and radiant eat, but of all electric and magnetic forces. The electrical ngineer is perfectly justified in retaining for the present, and rhaps for many years to come, the idea of a current, and of ssuming that it flows along a wire. He may be allowed also talk of transmitting energy through a wire, like water rough a pipe, although he knows that the current is only one ctor of energy, and that he does not "transmit" the other ctor, difference of potential, along with it in the same wire. ut those who care to make a better acquaintance with elec-ical science than is needful for designing a dynamo or work-g a cable, must face the ether theory. Additions are being ade to it year by year, and the student may well be per-exed as to the point at which he should commence to study . He certainly cannot plunge at once into Lord Kelvin's ypotheses, nor are Maxwell's equations intelligible without a evious acquaintance with optics. Mr. Glazebrook's Address aces the gradual development of the whole subject, and while me of the purely optical portions have been omitted, our stract will be found to contain all that concerns the electrical pect of this important subject.

An abstract of a further communication by Profs. Dewar nd Fleming to the *Philosophical Magazine* on "The Electrical esistance of Metals and Alloys," will be found in another lumn. The results of this very important research were ven in the form of Tables and on a large chart. We have itted most of the former, and in reproducing the latter we ve left out curves relating to platinum-silver, nickel-steel, atinum-rhodium, and thallium, these being uncommon etals. The resistance of these are all greater than nickel. e have omitted tin, palladium, cadmium, magnesium, and rious alloys, in order to avoid the crowding together of es on our reduced diagram. The greater curvature of the es of the magnetic metals than of the non-magnetic is rthy of notice.

Nearly a year ago we reprinted from the *Philosophical Magazine* the first communication by Profs. Dewar and Fleming on this subject. The authors published no diagrams, and we prepared three sets of curves from their tables. In each of these we gave a line representing absolute zero, – 274°C. In preparing the present diagram we have ventured to repeat this feature. But it will be seen that there is a discrepancy between the intersection of this line and of the platinum line with the axis of temperature. This discrepancy, however, is not without interest. The line is accurately placed at – 274deg. on the horizontal scale. But the authors explain that this scale is a convention, and they call it a scale of platinum degrees—that is, the platinum line is assumed to be a straight line. If the scale of the air thermometer had been employed for the higher temperatures, and had been extrapolated in a straight line for lower temperatures, the platinum line would be slightly curved. Mr. Callendar has shown that the difference from a straight line is nearly a parabolic function of the air thermometer temperature. This curved line would cut the straight line at two points, and at two only. Profs. Dewar and Fleming have provisionally chosen the two arbitrary points of 0°C. and 100°C., so there can be no coincidence at – 274deg., hence the discrepancy in our diagram, which thus shows very clearly the relation between the two scales. The platinum line being drawn straight by convention, the air line would be curved, starting from – 274deg. to the intersection of the platinum line with with 0deg., then crossing the platinum line, rising above it, and recrossing it at 100°C. The difference would for the most part be less than the thickness of the platinum line in our diagram.

That somewhat anomalous mode of acquiring knowledge of certain "useful" branches of natural science, which is commonly called technical education, has been discussed on many occasions in these columns. We have lamented its tendencies, and have called attention to the mischief which may arise if professors continue to attempt to teach details of engineering practice instead of confining themselves to the principles on which these details are based. It is unnecessary again to dwell at length on this subject, but we cannot allow Prof. Jamieson's Paper read at the Chicago Congress to pass without a protest. This Paper, entitled "London Electrical Engineering Laboratories," consists of three sections: I. Advantages of College laboratories and workshops; II. Should a college training precede, be combined with, or follow an

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apprenticeship? III. London electrical engineering laboratories. Early in the first section the author says, "it is possible to teach students how to turn, file, fit, and solder metals, how to joint wires and cables for telegraph, telephone, and electric light circuits. . . ." Possible, indeed! but to eight students out of ten, mere trifling, and perhaps to be afterwards unlearned. It would be "possible," indeed, for the foreman of an erecting shop to "teach" pupils the principles of thermodynamics, kinematics of machinery, theory of elasticity and strength of structures, to say nothing of the doctrine of armature reactions—after a fashion. Elsewhere in this section Prof. JAMIESON speaks of instructing students "in their everyday working details." Students who cannot afford to go through a proper course of physics must be content with useful bits of mechanics and electricity, but they should be studied as physics. Steam engines, boilers, dynamos, secondary batteries, and so on, should be used as laboratory instruments.

PROF. JAMIESON throws out several suggestions in connection with his second section, but answers the question by settling each case on its merits, which is no doubt satisfactory for the students, but does not give much information to outsiders. The third section, which gives the title to the Paper, appears to be based on a fortnight's visit to London, but Prof. JAMIESON could have written four-fifths of it from general knowledge. It is a pity that the admirable work of the technological or trade classes at Finsbury should be mixed up with the so-called technical education. Prof. JAMIESON speaks of two distinct sections, but does not sufficiently point out their different aims. "We must not forget to mention the Royal College of Science, . . . although the laboratory there is more of the nature of the Kelvin laboratory, . . . yet some very original, interesting, and instructive researches have been carried out in it by Prof. Boys, which have been of great use to electrical engineers." What a noble aim for Prof. Boys! How eagerly they await the results of his next research and wonder if it will be patented!

AFTER this the author gives a few details about institutions which he is able to appreciate, and finishes with one of the questions given at an examination for the diploma of his own college :—

"Go to the Faraday Works, Govan, and there make a complete set of freehand sketches of a ship lighting plant. From your sketches make a set of finished drawings. Take indicated horse-power cards, brake horse-power, and electrical horse-power tests at the normal speed and power of the engine and dynamos. Find the mechanical efficiency of the engine, the electrical and commercial efficiency of the dynamo, and write a concise report upon the suitability of the plant for the work it will have to do. You can take five days to this question. You are permittted to consult any book, but you must state the name of the book and the page whereon you get the information."

A delightful task for some men; but how much real work would it take to knock the conceit out of most students who, having done all this to the satisfaction of their teacher, and having criticised the "suitability of the plant," have duly received, framed and glazed, their richly-deserved diploma?

AN interesting return called for by the House of Com... has just been issued showing the revenue, expenditure... net revenue of the Post Office from 1870 to the present ... and in a form which is both novel and instructive. T... period selected is that during which the telegraph servi... been an adjunct of the postal department, but the respe... figures for each of the two services are not shown sepa... and, indeed, we should be left in some uncertainty ... whether the return relates to purely postal business ... not for the, as we should suppose, impossibility of e... apportioning the expenditure between it and the t... business. Be that as it may, the various columns ... return afford striking evidence of the magnitude of th... and the economy with which it is conducted by the ... Office. In these twenty-three years the revenue has ... than doubled, notwithstanding the many concessions ma... its customers in the way of cheapening the service since ... the still greater concessions to its servants in the shap... increased wages, yet the percentage of expenditure to rev... remains pretty much the same as it was. Salaries, s... annuation, and expenditure on buildings have increa... enormously—the percentage of the first-named alone to ... revenue having risen from 25·44 to 39·52. These additional expenses of management are partly counterbalanced, however, by reduced cost of conveying mails and of the tele... service. One notable feature of the return is that the ... revenue is shown after allowing for sites and buildings. ... the same principle the telegraphs would be entitled to cla... poles and wires in mitigation of net losses.

WE regret to record a fatal accident due to a shock fro... the 2,400 volt mains of the London Electric Supply Corpo... tion. On Tuesday last two men, ROBERT BALL and EDW... MEECH were at work in the Blackfriars sub-station. Th... are two sets of transformers stepping down from 10,000 vo... to 2,400 volts. Switches are arranged by which the secondary circuits of either or both sets of transformers can be connected to omnibus bars. The sets are alternately changed over for cleaning and examination, and in order to maintain continuity of supply, both sets are run in parallel for a time. With the intention of cleaning one of the sets which had been in ... the other was switched on, but by pure inadvertence the first one was not switched off. MEECH began to clean the fir... thinking they had been cut out of the circuit, when he received a severe shock. BALL pulled him off from the ... and apparently received a shock. Strange to say, Mr. ... though badly burned, recovered and found BALL dead, ... head wounded, apparently by falling back against a plank. MEECH is at St. Thomas's Hospital and is doing well, but we give little information about the accident.

ATTENTION will, of course, be paid to the prevention of su... an occurrence in future. Alternate blocking of the switches will not suffice, as both sets are run in parallel in switching over and during heavy loads. A partition or barrier with gate mechanically locked by a switch seems to meet the ... but the staff of the London Electric Supply Company will ...

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ɔubt, be able to devise an efficient arrangement. This is the ɔcond time in this country that a workman engaged in his ork on high-pressure conductors has received a fatal shock. n each case, the only protection has been a rule, the lives ave been forfeited by breaking the rule. In each case the ct was deliberate. Other accidents, not from fatal shocks, ut from falls, death being indirectly due to the shock, have kewise been due to non-observance of regulations.

Personal.—Mr. G. R. Neilson has been appointed Secretary ɔf the Europe and Azores Telegraph Company.

The Canadian Electrical Exhibition.—This Association met n Toronto on Tuesday, Wednesday, and Friday of this week.

Brighton.—The arc lights on the sea-front are to be switched ɔn to-morrow evening. The lamps are to be run off the private ɔupply mains.

Cable Interruptions and Repairs.—

	Dates of Interruptions.	Date of Repair.
Aden–Zanzibar	August 9th	September 9th.
Pernambuco—Ceara	September 1st	—

Proposed Electric Tramways at Halifax.—The proposal of ɔome electrical tramway promoters to introduce the overhead ɔrolly system into Halifax was c« nsidered at a meeting of the Town Council on Tuesday, and a resolution that the question ɔf constructing tramways should be adjourned *sine die* was ɔarried.

The Electric Light at the British Museum.—On Wednesday ɔvening last week for the first time the desks in the large ɔeading-room of the British Museum were lighted by nearly 200 115-volt 16-c.p. glow lamps. The large 30 ampere arcs have been replaced by Siemens band lamps, taking about 20 amperes.

Glasgow and West of Scotland Technical College.—The ɔession of this College commences on Monday, October 2nd. Information and syllabuses of the courses on engineering and other departments of applied and general sciences may be obtained from the Secretary. Further information will be found in our advertisement columns.

The Five-Wire System for Rotterdam.—Messrs. Siemens and Halske have obtained the contract for the Rotterdam Electricity Works, which are to form a municipal electric light and power supply system. The five-wire direct current system is to be used. Two sub-stations, about a mile and a mile and a-half respectively from the central station, supply the town light and power.

The Hague.—The Siemens and Halske station at the Hague, which was laid down in 1889, has ever since been undergoing constant extensions. The last additions to the plant comprise two interior pole 160 kilowatt machines, coupled direct to Storck engines, and a battery of 286 ampere-hour accumulators. The total plant capacity of this station now amounts to 1,000 H.P., of which the accumulators can supply 100 H.P.

Gas and Electric Light Companies in France.—A break has occurred at Compiègne in the judicial successes hitherto scored in France by the gas companies. The local gas company brought the usual action against the electric lighting company for infringing the monopoly given to it by its concession from the municipality. The Courts, however, held that the gas Company's monopoly related only to gas lighting.

Bristol University College.—The courses of lectures and laboratory instruction in electrical engineering, under Profs. Ryan and Chattock, will commence at this college on October 5th. These courses are arranged to extend over a period of three years, and arrangements can be made for students to spend the summer months in engineering workshops. A considerable number of engineering scholarships are attached to this college.

Telegraphic Communication with South America.—The Western Brazilian Telegraph Company notify that the telegraphic route to South America, owned by this Company, is completely opened, so far as messages to the River Plate are concerned. The notification by the Brazilian Government of the closing of traffic to Brazil, of course, only refers to the traffic intended for that country, transit messages to Monte Video and Buenos Ayres being in no way affected.

St. Pancras.—The St. Pancras Vestry, acting upon the advice of Prof. Henry Robinson, have authorised extensions of their electric lighting installation by the addition of three 90-unit engines and dynamos and three boilers at the existing Regent's Park station with another sub-station in Regent's Park-road. These extensions will enable a further 5,000 16-c.p. lamps installed to be served. The Vestry have also decided to construct a second electric lighting station in combination with a refuse destructor in King's-road.

The German Union of Electrical Engineers.—The annual meeting of this union, says *Industries and Iron*, is to be held at Cologne on the 27th, 28th, 29th, and 30th inst. Among the Papers to be read are the following:—"Impressions of the Chicago Exhibition and the Electrical Congress," by Dr. Budde; "On a System of Measurements for Central Electric Stations," by Dr. Kallmann; "Charging Accumulators by Means of Alternating-Current Machines," by Herr Pollak; "On the Development of House and Private Telegraphs and Telephones in connection with the Imperial Post," by Dr. Sack; and "On a New Insulation Testing Set, and an Incandescent Lamp Resistance," by Prof. Dr. Heim.

The Clark Standard Cell.—A Correction.—We have received the following note from Dr. K. Kahle with reference to an unfortunate error which crept into our translation of his memorandum on the preparation of the Clark standard cell:—"In the translation of my Paper, 'Instructions for Preparing Clark Standard Cells' (*Electrician*, July 7th, p. 265), I have just seen that there is an error. In describing the preparation of the sulphate of mercury you mention a solution of one part '*mercuric sulphate*' to 1,000 parts of water; it should be a solution of one part '*sulphuric acid*' to 1,000 parts of water, as is written in the original. I hope you will be so kind as to correct this in your journal."

List of the Official Delegates at the Chicago Congress.—The following is a complete list of the official delegates at the recent International Electrical Congress at Chicago:—*England*, Profs. Ayrton and Silvanus Thompson, Major-Gen. C. E. Webber, Mr. W. H. Preece, and Mr. Alexander Siemens; *United States*, Profs. H. A. Rowland, H. S. Carhart, T. C. Mendenhall, E. L. Nichols, and Elihu Thomson; *France*, MM. Hospitalier, Mascart, De la Touanne, Violle, and Dr. S. Leduc; *Germany*, Prof. von Helmholtz, Dr. Emil Budde, Dr. Otto Lummer, Herr Schnaeder, and Prof. Voigt; *Italy*, Prof. Galileo Ferraris; *Austria*, Dr. J. Sahulka; *Switzerland*, Dr. A. Palaz, Prof. Réné Thury, and Prof. Weber; *Sweden*, M. Wennmann; *Mexico*, Senor Don A. M. Chavez; *British North America*, Mr. Arthur Higman.

Charterhouse Science and Art Schools and Literary Institution.—The winter session of this, one of the largest science and art schools in the United Kingdom, will commence on Saturday, September 23, 1893, under the Presidency of the Rev. H. Swann, M.A. During the late session upwards of 300 students, mostly elementary teachers, availed themselves of the privileges afforded by this Institute, and a large number presented themselves for examination, and were successful in obtaining advanced certificates, and also a fair number of honors awarded by the Science and Art Department of South Kensington. The grants earned by the students were far in excess of those of any previous year. Instruction of a practical character is given in most of the sciences at a nominal fee; and in art at an equally low rate. Students under the direction of many competent instructors can be advanced in their studies.

Electrical Communication with Lighthouses.—In a supplementary estimate recently issued, £10,000 is required for carrying out works recommended by the Royal Commission on Electrical Communication with Lighthouses. In connection with this, the President of the Board of Trade stated in the House of Commons last week that the work of connecting the Kentish Knock light-vessel with the shore by

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telephone was now in progress. Lundy Island had been connected. Either the Tuskar or Gunfleet light would be put in hand at once, and the Chancellor of the Exchequer had also authorised the connection of the Goodwin (North Sand Head) light-vessel. All the shore lighthouses recommended, except that at the Needles, which was now in hand, had been already telephonically connected with the land. The experiment of connecting the Fastnet lighthouse with Crookhaven by a non-continuous cable had not yet been carried out.

The Telegraph in the Field.—The part likely to be played in any future war by the military telegraphs is admirably brought out by *The Times* correspondent, present at the autumn manœuvres. Referring to some clever manœuvring, the correspondent remarks:—"The situation when the telegraph was utilised was almost identical with that on the left flank of the French at Worth at 10:30 a.m. on August 6, 1870. In 1870 Von Kirchbach, attacking in front, had no wire connecting him with the Bavarians out of his sight on his right flank, and consequently the attack was isolated, involving failure and the unnecessary loss of thousands of lives. Now science has provided the connection; and from two different points of the compass forces can advance in absolute and methodical combination, and, acting together, accomplish their task successfully. The Royal Engineer Telegraph Battalion may fairly be credited with no small share in the crushing blow inflicted on the enemy's left flank at the battle of Seven Barrows."

Police Telephones.—The following paragraph from the *Essex County Chronicle* is typical of the present chaos in matters telephonic. At the last meeting of the Standing Joint Committee of the Essex County Council:—"The Clerk reported numerous difficulties which stood in the way of carrying out the tender of the National Telephone Company for the construction of telephonic communication for the police between Chelmsford, Brentwood, Romford, and London. The Romford Local Board wanted the wires underground, the Chelmsford Town Council wished to see the plans before giving any sanction to the scheme, while the Telephone Company stated that their tender, which was £121. 10s. per annum, was for the erection of poles and wires, and did not include the cost of any underground work."—Capt. Showers recommended that the tender of the Post Office for the establishment of the required communication be accepted at a cost of £135 per annum.—The recommendation was agreed to.

The Antwerp Electro-Hydraulic Scheme.—The scheme of combined hydraulic and electric distribution inaugurated at Antwerp by M. Van Rysselberghe is, we believe, to go forward notwithstanding the untimely death of its progenitor, and the following particulars relating to it may, therefore, be of interest. The agreement with the Antwerp municipality stipulates for the laying down of at least 8 kilometres of hydraulic and 16 kilometres of electric mains, to begin with; the resistance of the electric mains not to exceed 0·2 ohm per kilometre. The first hydraulic station is to be of about 500 H.P., and capable of sending 75 litres (15 gallons) of water per second into the mains at a pressure of 52·5 atmospheres (776lb. to the sq. in., or 1,785ft. head). In justifying his scheme before the municipal authorities M. Van Rysselberghe argued that 12 16-c.p. lamps could be obtained for the expenditure of one horse-power, and as one horse-power hour could be obtained from 2⅗lb. of coal the *coal* bill for one 16-c.p. lamp for one hour only came to 0·0125d., whilst the gas for a burner giving the same light cost ½d. an hour with gas at 5s. a thousand. Why is it, then, said M Van Rysselberghe, that electricians cannot undersell gas? Because of the loss in transmission to the consumer. Get rid of this loss, argued M. Van Rysselberghe, and we shall see what we shall see. This argument, although it did not take into account a source of loss which has made itself painfully evident in this country, namely, the loss caused by an irregular demand, convinced the Antwerp municipality, and M. Van Rysselberghe was given a concession for an hydraulic power station which is to transmit power by high-pressure water to turbines driving dynamos placed in small sub-stations and feeding into a low-pressure two-wire network; hydraulic power is also to be supplied direct to lifts, &c. Electricity is to be sold at a maximum price of 8d. per kilowatt hour, and water-power at 4½d. the cubic metre under a minimum pressure of 47½ atmospheres.

Technical Instruction.—A Parliamentary paper just published gives an abstract of returns furnished to the Department of Science and Art, showing the manner in which, and the extent to which, technical instruction is being fostered by local authorities. The returns were made in response to a letter sent to them last Session by the Education Department. Of the 49 counties in England, 42 apply the whole amount of the residue received under the Local Taxation (Customs and Excise) Act, 1890, to technical education, and the remaining 7 apply a part of the residue. Of the 61 county boroughs, 47 apply the whole and 10 part of the residue. Of the 13 counties in Wales (including Monmouth, to which the Welsh Intermediate Education Act, 1889, applies), 12 apply the whole and 1 a part of the residue, Six counties levy a rate or make grants out of the rates, under the Technical Instruction Act, 1889; and all 13 levy a rate under the Welsh Intermediate Education Act, 1889. The three county boroughs all apply the whole of the residue to technical education under the Welsh Intermediate Education Act, 1889, and levy a rate under the same Act, and one borough also levies a rate or makes grants out of the rates under the Technical Instruction Act, 1889. Of the 33 counties in Scotland 20 apply the whole of the residue to technical education, 6 apply a part, 4 are considering the question, and 2 apply the whole of the residue to the relief of the rates. Of 82 burghs, only 7 apply the whole to technical instruction, 21 a part, 1 was considering the question, 51 apply the whole residue to relief of the rates, and 2 made no returns. Of 105 police burghs, nine apply the whole to technical instruction, 18 a part, 9 were considering, and 66 apply the whole to the relief of rates.

Papers read at the Chicago Congress.—The following is a complete list of the papers actually read, or taken as read, at the recent International Electrical Congress at Chicago:—"On the Analytical Treatment of Alternating Currents," by Prof. A. Macfarlane, of Texas University; "Complex Quantities and their Application to Electrical Engineering," by Mr. C. P. Steinmetz; "General Discussion of the Current Flow in Two Mutually-Related Circuits containing Capacity," by Drs. Bedell and Crehore; "Explanation of the Ferranti Phenomenon," by Dr. Johann Sahulka, of the Technische Hochschule of Vienna; "Measuring the Power of Polyphase Currents," by A. Blondel; "Extended Use of the Name Resistance in Alternating-Current Problems," by Prof. W. E. Ayrton; "Transmission of Electrical Signals through Space," by Mr. W. H. Preece; "Ocean Telephony," by Prof. S. P. Thompson; "On the best Value for Resistance Coils," by Dr. Lindeck; "On the Temperature Coefficient of Copper," by Mr. A. E. Kennelly; "On Photometric Measurements," by Prof. Thomas; "On Electrostatic Voltmeters," by Prof. Carhart; "On a Method of Governing an Electric Motor for Chronographic Purposes," by Prof. Webster; "On Iron for Transformers," by Prof. Ewing; "London Electrical Engineering Laboratories," by Prof. Andrew Jamieson; "Transformer Diagrams Experimentally Determined," by Dr. Bedell; "On an Improved Instrument for Measuring Magnetic Reluctance," by Mr. A. E. Kennelly; "Variation of the Potential Difference of the Arc with Current, Size of Carbons, and Distance Apart," by Prof. W. E. Ayrton; "Light and Heat of the Arc," by M. Violle; "The Swinburne-Thompson Unit of Light," by Prof. S. P. Thompson; "Periodic Variation of the Candle-Power of Alternating Arc Lights," by Prof. B F. Thomas; "Maximum Efficiency of Arc Lamps with Constant Number of Watts," by Prof. Carhart; "On New Researches with the Alternating-Current Arc" and "On the Constant-Current Arc and its Employment as a Standard of Light," by M. Blondel; "Source and Effects of Harmonics," by Prof. Rowland; "Rotary Mercurial Air-Pumps," by Mr. F. Shulze-Berge; "Underground Electric Construction in the United States," by Prof. D. C. Jackson; "Various Uses of the Electrostatic Voltmeter," by Mr. F. Sahulka; "The New Incandescent Arc Light," by Prof. L. B. Marks; "On Direct-Current Dynamos of Very High Potential," by Prof. F. B. Crocker.

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ELECTROMAGNETIC THEORY.—LIV.

BY OLIVER HEAVISIDE.

(Continued from page 439.)

§210. Although the equations connecting the voltage V and ,aussage C, through the line constants R, S, K, and L, are of , symmetrical character, so that, abstractedly considered, a tudy of the nature of their propagation on either side of the listortionless state is as desirable as on the other side; yet when we examine the conditions prevailing in practice, we see at once that one side only presents itself actively. The reason is easily to be seen. It is in all cases desired to get plenty of received current, because that is the working agent, and leakage is detrimental to this consummation. There are, besides, practical inconveniences connected with leakage. Thus it comes about that we are mainly concerned with the state of things existing when R/L is greater than, or at the least equal to K/S, and scarcely at all with the exceptional case of an excess of leakage, unless it be as a curiosity, and for the sake of its theoretical connection with other electromagnetic problems.

Now this concerns the propagation of V and C through the external dielectric. The influence of R prevails over that of K, and controls matters. It is, however, somewhat remarkable that the other side of the propagation problem does actually present itself actively, when we regard the important secondary effect of the propagation into the guides of the cylindrical waves, which result from the passage over them of the plane waves in the external dielectric. Suppose, for example, there is no external conductance. This gives one extreme form of propagation of V and C, the quantity K/S (or equivalently k/c), being zero, and R/L finite. Now, remember that in the exact plane wave theory R stands for the magnetic conductance of the external medium, so that R/L is the same as g/μ, and therefore we are, when considering V and C, also discussing the influence upon the plane waves of the fictitious property of magnetic conductance.

On the other hand, in the guides themselves, which are electrical conductors, and perhaps, and most probably, dielectrics as well, it is k/c that is greater than g/μ, since the latter is zero. Here, then, we have the other extreme form of the theory. In the external dielectric k/c is zero and g/μ (equivalent to R/L) finite, whereas in the guides is zero and $g/\mu k/c$ finite. The distortion of the external plane waves by the resistance of the guides is, therefore, of the opposite kind to that of the cylindrical waves in the guides, for **E** and **H** change places when the form of the distortion is discussed.

Now, in the guides, on account of their being very good conductors, the permittivity is swamped, and it may be ignored in calculating resultant effects. Then we have the theory of pure diffusion (as of heat according to Fourier), controlled by the *two* constants k and μ, since both g and c are now zero. Similarly, in the external dielectric, it may happen that the influence of μ (or equivalently of L) is insensible, as in the slow working of long cables; then the propagation of V and C is controlled by the *two* constants g and c (or actually and equivalently by R and S), whilst the other two, k and μ, are zero. Here, then, we have a curious exchange of active properties between the dielectric and the conductor. In both, the resultant propagation follows the diffusion law, but is controlled by different properties. The propagation of V or **E** outside is like that of **H** inside, and the propagation of C or **H** outside is like that of **E** inside.

We see by the above illustrations that in spite of the absence of magnetic conductivity in reality, we are, nevertheless, obliged to consider both sides of the wave-theory it involves, even in one and the same actual problem, provided it be treated comprehensively.

§211. As, however, we are not immediately concerned with the internal state of the guides, and, so to speak, eliminate them by treating R and L as constants, we may now dismiss their consideration, and return to V and C only, on our understanding that the quantity K/S is always less than R/L, or does not exceed it in the limit.

Now we have shown that the distortion in transit depends upon the difference

$$\sigma = \frac{R}{2L} - \frac{K}{2S}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

whilst the attenuation of the front of an advancing wave depends upon the sum

$$\rho = \frac{R}{2L} + \frac{K}{2S}. \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Both σ and ρ should be as small as possible, of course. The four line-constants act upon ρ and σ in different ways, and it is rather important to understand them. So, remembering that the first term of the right members of (9) and (10) is bigger than the second, observe the effect of varying the line-constants, one at a time.

[R]. By increasing R we increase both ρ and σ. Thus the resistance of the guides is wholly prejudicial, since it not only weakens signals in transit, but distorts them. It is, therefore, a fundamental notion that the resistance of the guides should be reduced if possible, but never increased, if the object be to facilitate signalling.

[L]. By increasing L we decrease both ρ and σ. Thus the inductance of the circuit (other things being equal) is wholly beneficial, since it diminishes both the attenuation and the distortion in transit, or makes the received signals both larger and plainer. These are not necessarily insignificant effects, but may be very large when applied to very rapid vibrations on a long circuit

[K]. Increasing K increases ρ and reduces σ. Thus leakage is both beneficial and prejudicial, according to circumstances, since although it reduces the distortion, it simultaneously increases the attenuation in transit. This action is most pronounced when the signalling is slow.

[S]. Increasing S increases σ and reduces ρ. It may be, therefore, both prejudicial and beneficial. But practically the important effect of S, notably on cables, is the prejudicial one of distorting the signals, which is a large effect.

Now the above statements, though obviously true enough as deductions from (9) and (10), are merely qualitative. The practical import of varying one quantity when three others are constant, depends upon the actual immediate values of all four. The length of the line also comes in as an important factor, and likewise the frequency of the waves, to settle under what circumstances this or that variation of the line constants is important in a special case. Nevertheless, the above properties are important, and should be most usefully borne in mind in general reasoning, as well as in the detailed examination of formulæ, for instance, the important solutions for simply periodic waves.

Some of these effects have been known and understood from the earliest times, or, more correctly, since the time when William Thomson taught telegraph cable engineers the principles of their business (in its electrical aspects), and, to a great extent, the practice too. They were previously in quite a benighted state, generally speaking, though there were a few, whose names it is needless to mention, who combined enough electrical science with their practical knowledge to have fairly correct ideas about retardation in submarine cables. I do not mention Faraday in this connection, for that great genius had all sorts of original notions, wrong as well as right, and not being a mathematician, could not effectively discriminate, especially as he had so little practical experience with cables.

A complete history of the subject of the rise of Atlantic telegraphy, including the scientific side, written by a man fully and accurately acquainted with the facts, preferably with personal knowledge, and devoid of personal bias, would be of great value and of permanent utility. It will not be very long before no contemporary will be left to do it. Perhaps, on the other hand, it might be more fairly done at second hand. In the meantime, there is a somewhat bulky volume, the Report of the Submarine Cable Committee of 1859, which serves to show the state of knowledge at that date. But it is the history of the march of knowledge in the several preceding years that is important.

The two effects referred to are that resistance and permittance (R and S) act conjointly in producing "retardation," so

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that both R and S should be reduced to improve the electrical efficiency of a cable. This is embodied in Lord Kelvin's theory of 1855, and gave rise to a rather neat law of the squares, something that practicians could grasp. This law soon became matter of common knowledge amongst cable engineers and electricians generally. But when once grasped they could not let go, and in later times the law has been most grossly abused and misapplied. The fact still remains, however, that R and S are prejudicial. But allowance has to be made for other influences, and it may be very large allowance.

But, very curiously, there has been an exception to the rule. There have not been wanting electricians who, when telephony was extended to circuits containing underground work, supposed that high, not low resistance, was good for telephony. This was giving up the law of the squares with a vengeance. But there was really no warrant for such a conclusion, either theoretical or practical. As this view turned out manifestly wrong by practical failure, it was followed by a precipitate revulsion, the law of the squares being again seized, and grasped more firmly than ever, and against all reason. The fact that R and S are prejudicial does not make the law of the squares. To have that, R and S must be the only controlling electrical factors.

All the other effects are of later recognition, and were mostly discovered, and their laws investigated, and consequences worked out by myself. They completely remodel the subject. The old views remain right, in their proper application, but have a very limited application in general, as in modern telephony particularly. My extended theory opened out a wide field for possible improvements in signalling over long circuits in advance of what could be possible were R and S the only controlling factors, and so far as it goes, modern telephony already goes far beyond the supposed restrictions of the law of the squares.

We should not only consider the effects of varying the four line constants one at a time, but also of combinations. Thus, K may be counteracted by L. The former is beneficial, inasmuch as it lessens the distortion, but it is prejudicial in the attenuation it causes in transit. But if we simultaneously increase L, we counteract the attenuation caused by K; moreover, we still further lessen the distortion. This is corroborative of the preceding remark as to the unreserved benefit due to L. We see, therefore, that [K] and [L] above point the way to salvation, if that be by means of increasing the distance through which signalling can be carried on with a cable of given type as regards R and S. But let it not be forgotten in studying K and L, that R and S themselves might perhaps (in some particular scheme, for example) be reduced as cheaply as K and L could be carried out. Be liberal with the copper, for one thing. Look out for some practical way of insulating the wires which shall not make the permittance be so great as it is at present with gutta-percha or india-rubber. Something of this sort has been done for telephone underground cables, though I do not know the practical merits. But, as regards Atlantic cables, it should be something very good and trustworthy, or the reduced permittance may be bought too dearly.

There has been some difficulty in getting people to grasp the ideas embodied in [K] and [L], especially the latter, of course, on account of its novelty; whilst [K] was already partially recognised by knowing ones, and is capable of very ready explanation. [L] was the trouble. Now, remembering the state of fog that prevailed in the fifties as regards the effects of R and S alone, there is no reason for wonder that more recondite effects, as of L, unaccompanied by prior experience, should not be readily recognised when pointed out, though that was no excuse for burking the matter. [K] and [L], especially the latter, require to be studied to be understood. But if people will not take the trouble to study the matter, how can they expect to understand it? Now I find that there has been too much of an idea that I have merely given some very complicated formula which no fellow can understand, and have made some dogmatic and paradoxical statements about the consequences. But a reference to my "Electrical Papers" will show that I have treated the matter of propagation very fully, in the elementary parts as well as in the advanced, and from many points of view, and that I have not been above pointing the moral by numerical examination of results, whilst at the same time I have been particularly careful in elaborating the theory of the distortionless circuit, on account of its casting so much light upon the subject generally. The notion that has been promulgated, that I cannot make myself understood to physicists, recoils upon its authors with great force. Letting alone the fact that some physicists have understood me, and moreover, the fact that various students have understood me (as I know by my correspondence), there is the very notable fact that the promulgators of the false idea (which must be most discouraging to students) have evidently not taken the trouble to examine my writings to see what my views really are, but have only made acquaintance with a fragment thereof. I have advertised the distortionless circuit so often that I have become ashamed of doing so. Nevertheless, since it is, as I have often pointed out, the royal road to an inner understanding of the subject in general, I do not hesitate now to add some more remarks in connection therewith, and leading up thereto, in attempted elucidation of former work. We should first consider [K] alone, or in conjunction with [R] and [S], and then [L], and finally both [K] and [L].

§ 212. What leakage does is to increase the attenuation of waves in transit, but at the same time to lessen the distortion they suffer. Now there is, by elementary knowledge, no difficulty in seeing why leakage on the line should diminish the strength of the received current, in spite of the fact that the strength of the current sent is increased by the leakage. Ohm's law applied to a simple circuit with a shunt attached will suffice to give the reason so far as one fault is concerned; and the principle is the same for any number of faults, or for distributed leakages.

As regards the lessening of the distortion, that is not quite so elementary. It does not present itself for consideration at all in common telegraph circuits. When, however, a cable is in question, and there is manifest distortion of signals, the influence thereupon of leakage becomes an obvious matter of inquiry. We may do it on the basis of the electrostatic theory. In fact, in his telegraph theory, Lord Kelvin did insert a term in the differential equation to express the effect on the potential of uniform leakage, though it was merely in passing, and I do not think there was any development of the matter in his later papers. The obvious attenuating effect of leakage, and the manifest evils of faults, caused high insulation to be aimed at, and possibly caused the full effect of leakage to be overlooked, and its theory to remain uninvestigated.

Now a cable is a condenser, or leyden, and a very big one too, although its permittance is so widespread that the permittance of a yard or so is very small. The discharge of a condenser against resistance takes time, and so does its charge, and the greater the resistance the greater the time needed. In the extreme, a perfectly insulated charged condenser keeps its charge unchanged, and so does a well-insulated cable, if also insulated at the ends. Even when it is earthed (or grounded, as the Americans say) at both its ends, only the portions close to the end can discharge at once. Away from the ends, the discharge has to take place through resistance, to a varying extent though in different parts, when we regard the long cylindrical condenser as a collection of small condensers side by side in parallel, with all the similar poles joined together by resisting wires. This is how it comes about that the resistance acts conjointly with the permittance in causing "retardation" in cables, so that the electrostatic time-constant is proportional to their product, or RSl^2. It is obvious, then, that we can facilitate the discharge by lessening the resistance to discharge, that is, by leakage in the cable, either distributed or in detached lumps. At the same time the charging is similarly facilitated or expedited.

Now, in making signals from end to end, the operation of charging the cable is necessarily precedent to that of receiving current at the distant end, which, in fact, represents a part of the charge coming out. Therefore, to expedite changes in the charge in the cable, not necessarily or usually complete charges or discharges, results in expediting changes in the current at the distant end. That is, it lessens the distortion at a given working speed, and so expedites the signalling. There is, in

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; electrostatic theory, no limit to this process, and by suffi ntly reducing the insulation resistance, or, which is the same, reasing the leakance (which is, perhaps, an admissible short ne for leakage conductance), we might signal through the ble as fast as we pleased, were there no other effect produced. is other effect is the extra attenuation. Whilst the possible eed of signalling can be raised apparently *ad lib.*, there is ly an infinitesimal current left to do it with. (Remember at the influence of L is not now in question.) It is important recognise that it is a consequence or natural extension of the l electrostatic theory, without any appeal to self-induction, at you can signal as fast as you like through an Atlantic ble of the present type (with leakage added, of course) simply throwing away most of the current, and utilising the small siduum that manages to survive the ordeal.

Thus, a proper Atlantic cable, suitable for rapid signalling, ould not have high insulation resistance, but the very lowest ssible consistent with getting enough current through to rk with, and other considerations, mechanical and com- ercial, &c. The theory, moreover, is a sufficiently clear one, d does not need elaborate mathematics to make it at least obably accurate, though it may, of course, be desirable to oroughly verify the consequences mathematically.

It is now about 23 years since I came to see, substantially above, the theoretical absurdity of a system of signalling ich deliberately and seemingly of purpose places in the ay the greatest possibly hindrance to the efficient trans- ssion of signals, viz., by the use of the highest insulation ssible, causing them to be regularly strangled, choked, and itilated, to say nothing of their sometimes dying of inanition. But this was mere theory. As a matter of fact, the effect leakage presented itself to me at that time in practice real live cables in a surprisingly different manner. The position between plausible theory and live practice was so aring that it will be instructive to briefly describe it next thus.

(*To be continued.*)

LANDMARKS IN THE HISTORY OF ELECTRO-CHEMISTRY.*

BY W. W. HALDANE GEE, B.SC., F.C.S.

(*Continued from page 501.*)

Dr. William Henry, of Manchester, was also occupied with ectro-chemical experiments. His chemical library was pre- nted to the Owens College by Dr. Charles Henry, F.R.S. o this valuable collection of works reference has been re- atedly made in the preparation of this article.† His "Ex- riments on Carbonated Hydrogen Gas, with a view to deter- ine whether Carbon be a Simple or a Compound Substance," ere published in *Phil. Trans.*, LXXXVII., p. 401, 1797, and mbat the view of Dr. Austin (*Phil. Trans.*, LXXX.), that the ex- ansion of this gas that occurs when electric shocks are passed rough it is due to the decomposition of carbon, and the sub- ance is still to be considered as an elementary substance— at is, as a body, "with the composition of which we are un- quainted, but which may, nevertheless, yield to the labours some future and more successful analyst."

His next series of "Experiments for Decomposing Muriatic cid" appear in *Phil. Trans.*, XC., p. 188, 1800. It was an portant problem to analyse hydrochloric acid, the theory f the nature of acids being regarded as still incomplete nd liable to subversion, until each acid had been resolved nto its individual constituents. Hydrochloric acid gas was confined over mercury in straight glass tubes, furnished at the sealed end with a conductor of gold or platinum. Electric shocks from a frictional apparatus were passed through the gas. The shocks were as strong as could be given without breaking the tube; in some cases, indeed, the apparatus was shattered. After many experiments, in which shocks from 20 to 400 in number were passed, hydrogen and calomel were obtained. In order to avoid the action of the mercury, Mr. Cuthbertson made him a glass tube ground at one end, with the view of receiving two stoppers, each perforated with platinum wire, so that electrical shocks could be passed through any gases with only glass and platinum in contact. With this apparatus he made the following experiment:—

"Experiment 7. In this tube I electrified the muriatic acid gas, and then admitted to it an infusion of litmus. The sudden destruction of its colour evinced the formation of oxygenated muriatic acid. Not the smallest deposit appeared in the tube."

Henry had, in fact, decomposed hydrochloric acid, but in the light of the views then held chlorine was regarded as a compound of hydrochloric acid and oxygen, and Henry supposed its production in this experiment to be owing to the presence of moisture. Biassed by the prevailing theory, he came to the conclusion "that he had not made the smallest progress in decomposing hydrochloric acid." If chlorine contained oxygen it would be expected to yield water if electrified with marsh gas. He accordingly made a mixture of the two gases, to which he gave in different cases shocks to the number of 200 and even 1,000. The result was simply negative.

John Dalton describes in his "New System of Chemical Philosophy," Part II., 1810, many electro-chemical experiments, some of which were made with the assistance of Dr. Henry. Dalton repeatedly used the eudiometer of Volta and the method of analysis of applying repeated electric shocks to ascertain the composition of gases. Many of the experiments had not been previously published, for he was determined to write as little as possible but what he had verified by his own experience. On this account the following electro-chemical references are noteworthy:—

Page 228. Oxygenous gas is not sensibly affected by continually passing electric sparks or shocks through it.

Page 231. Hydrogen gas bears electrification without any change.

Page 234. Azotic gas is not affected by repeated electrification.

Page 285. The experiments of Henry (*Phil. Trans.*, 1800) on the decomposition of fluoric acid are repeated. He electrified a mixture of fluoric acid and hydrogen by a dense stream of sparks for three hours, and noticed a diminution in volume.

Page. 293. A number of experiments on the decomposition of muriatic acid by electric shocks are described.

Page 304. He spent much time in endeavouring to ascertain the composition of oxymuriatic acid.

Pages 321 and 322. Repetition of Priestley's experiment of electrifying nitrous gas and of the Cavendish experiment of synthesis of nitrogen compounds.

Page 374. Pure carbonic oxide is not at all affected by electricity. "I was present when Dr. Henry conducted an experiment in which 35 measures of carbonic oxide received 1,100 small shocks" without decomposition.

Page 382. Carbonic acid is decomposed by electricity into carbonic oxide and oxygen. "I assisted Dr. Henry in an experiment by which 52 measures of carbonic acid were made 95 measures by 750 shocks."

Page 440. When olefiant gas is subjected to electricity either over mercury or water the result is hydrogen, and a quantity of charcoal is deposited. A very careful experiment made in conjunction with Dr. Henry is described.

There are similar experiments relating to other gases, furnishing Dalton with the desired data for the foundations of his great Atomic Theory.

The *Philosophical Transactions* for 1800 contains a letter from Signor Volta, Professor in the University of Pavia. This was the first intimation of the discovery of a new and powerful means of generating electricity, which he thus describes: "I obtained several dozen small round plates or discs of copper, brass, or, better, of silver, about an inch in diameter; for

* The substance of these articles was originally read at a meeting of the wens College Chemical Society. For some help in preparing for publica- on I am indebted to Mr. Vaughan Cornish, M.Sc., F.C.S.

† The three Henrys—Thomas, William, and William Charles—filled an portant place in the History of Science in Manchester. The second one generally considered the most eminent of the three. He published The Elements of Experimental Chemistry," which in 1809 had passed rough eleven editions. *See* Dr. Angus Smith's "A Centenary of Science Manchester," published by the Literary and Philosophical Society of anchester.

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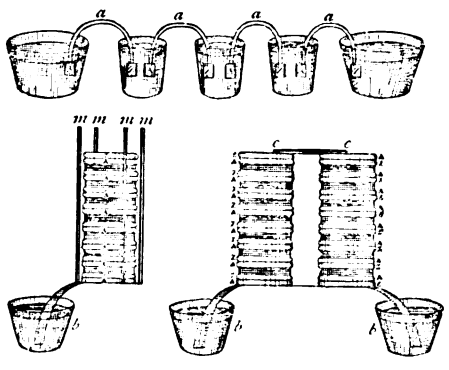
example, pieces of money, and an equal number of pieces of tin, or, better, of zinc of nearly the same shape and thickness. I say nearly because exactness is not required, and the diameter, as well as the thickness, is arbitrary; it is only necessary to see that the discs are rightly arranged in the form of a column. I prepare next a number of discs of card, or other material capable of imbibing and retaining a liquid. These, which I will call the moistened discs, are rather smaller than the metal plates. One of the metal plates, *e.g.*, of silver, is laid on a moistened disc, and on this is placed a plate of zinc, and on this a moistened disc, followed immediately by silver, which is again succeeded by a moistened disc, and so the apparatus is built up." Fig. 5 shows several arrangements of the apparatus. Twenty pairs were found capable of giving a shock, and many strictly electrical effects were made manifest. When a plate connected with one end of the apparatus was placed on the tongue, and connection was made between the head and the other end of the apparatus, a flash appeared before the eye, and a taste was perceived in the mouth. When metal rods connected with the apparatus were inserted in the ears a peculiar crackling or boiling sound was heard, but Volta did not think it prudent to make the experiment repeatedly. In some of the experiments the *pile* was replaced by a row of glass vessels containing water, or a salt solution, in which were plunged zinc and silver, the arrangement being termed by Volta the *couronne de tasses* (Fig. 4).



FIGS. 4 and 5.—Couronne de Tasses and Volta's Pile.

The publication of Volta's experiments at once excited great interest among philosophers. Anthony Carlisle, a surgeon, with his friend William Nicholson, made experiments described in *Nicholson's Journal* for July, 1800.* Mr. Carlisle constructed one of the galvanic combinations with half-crowns and plates of zinc, with pasteboard soaked in salt water. The pile gave shocks such as Volta had described, and it was ascertained that the effects were without doubt electrical. "Very early in the experiments," says Mr. Nicholson, "the contacts being made sure by placing a drop of water upon the upper plate, I observed a disengagement of gas round the touching wire. The gas, though very minute in quantity, evidently seemed to me to have the smell afforded by hydrogen when the wire of communication was steel. This, with some other facts, led me to propose to break the circuit by the substitution of a tube of water with two wires. On May 2nd we, therefore, inserted a brass wire through each of two corks inserted in a glass tube of half an inch internal diameter. This compound discharger was applied so that the external ends of the wire were in contact with the two poles of the pile." With a pile of 36 half-crowns and zinc plates, a fine stream of minute bubbles immediately began to flow from the point of the lower wire which communicated with the silver, whilst the other wire became tarnished. In two and a-half hours two-thirds of a cubic inch of gas was collected. This was mixed with an equal quantity of common air and exploded. The experimenters from the first believed that water had been decomposed, and that oxygen had attached itself to the upper wire, but it was a matter of great surprise that the oxygen came off at a place two inches distant from the hydrogen. "The decomposition of water and oxidation of metallic wire gave birth to a variety of speculations and projects of experiments." It was found that when wires of platinum were used bubbles came off from both wires. An attempt was made to collect the gases. With a pile of 68 pairs the process was continued for 13 hours. The gases collected were then decanted into separate bottles. On measuring the quantities, which was done by weighing the bottles, it was found that the quantities of water displaced were, respectively, 72 grains on the zinc side, and 142 grains on the silver side, or nearly in the ratio of one to two.

A pile of 100 half-crowns and a like number of zinc plates was next employed. With this pile Mr. Nicholson observed a chemical phenomenon which appeared to him the most remarkable he had yet observed. When copper wires were used, and dilute hydrochloric acid instead of water was placed in the tube, there was a deposit of copper which increased so as to form a metallic vegetation.

Cruickshank,* of Woolwich, repeated and extended these experiments; using a pile of 100 pairs, he decomposed lead acetate (sugar of lead), copper sulphate, and silver nitrate. With the last the metal shot out into fine needles, like crystals, articulated as in the *arbor Dianæ*. He also drew attention to the fact that alkalies always were liberated at the negative and acids at the positive pole. The name of Cruickshank is chiefly remembered for the battery he invented, consisting of zinc and copper plates inserted in a trough.

As the galvanic apparatus became better known it excited much interest, and Volta, its discoverer, was highly eulogised. The National Institute of France presented him with a gold medal, and the French Government bestowed on him 6,000 francs as a mark of esteem. Pile building became a fashionable pastime, and the changes were rung on the metals and liquids employed. Thus Colonel Haldane set himself the task of comparing the effects obtainable with zinc, gold, silver, iron, copper, lead, tin, and mercury, trying the effect of each pair of metals except, indeed, of gold with mercury, and of silver with mercury, a restriction only reasonable considering that the silver was represented by 20 to 200 half-crowns, and the gold by 40 to 56 guineas. The intense interest excited by the subject of galvanism is thus described in the introduction to the *Recherches Physico-Chimiques* of Gay-Lussac and Thenard: "What an impulse has been given to research by the discovery of the pile! What enthusiasm it has excited! Everyone is making piles of every conceivable variety of form. Societies are formed with the sole object of making observations on them, and everybody wants to understand them."†

(To be concluded.)

THE TRANSMISSION OF ELECTRIC SIGNALS THROUGH SPACE.

Nearly a year ago we commented on a description in *The Times* of some experiments made by Mr. Preece on telegraphy without wires. The details then given were very vague, and some suggestion was made about the use of Hertzian oscillations. We observed that the effects might be explained by

* "Account of the new electrical or galvanic apparatus of Volta and experiments performed with the same.—W.N."

* *Nicholson's Journal*, July, 1800.

† Becquerel ("Traité Experimental de l'Électricité," T. I., p. 108) makes the following significant remarks:—"Une société galvanique s'organisa à Paris vers le commencement de l'an XI. Elle était composée de médecins et de physiciens, qui devaient s'occuper spécialment et exclusivement de tout ce qui avait rapport à la découverte de Galvani. Cette société s'organisa, forma des commissions, fit même des expériences, mais il n'en est résulté aucune découverte nouvelle. Il en arrive toujours ainsi dans les réunions composées d'un grand nombre de savants; on discute, puis l'on se sépare. Les découvertes sont ordinairement l'œuvre d'un seul non de plusieurs."

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urrents returning through the earth rather than by induction, nd ventured to hope that when the time came for Mr. Preece o describe his experiments with his usual lucidity, the confusion nd ambiguity of this preliminary bit of newspaper science ould matter little. The time has come, but we regret that ır wish has been by no means gratified. A Paper has been ad at Chicago by the author of these experiments, but though e have given it most careful attention, we must confess that ıe theoretical conclusions as well as the description of the ıperiments are of an indefinite character.

After a brief and introductory summary of earlier experiments, ection 1 begins as follows :—"When a linear conductor dips ; each end into the earth, with which it makes a good con- ection, and voltage is impressed upon it by any means, the sulting return current would probably flow through the earth a straight line between these two points if the conduction of ıe earth were perfect ; but as the earth, *per se*, is a very poor nductor indeed (and probably is a conductor only because it moist), lines of current flow spread about symmetrically in a ay that recalls the figure of a magnetic field. These diffused turn earth-conduction currents are evident at great dis- nces."

A diagram follows, showing the paths of the return currents. ssuming that the earth is homogeneous, and that the distor- ɔn of earth currents by regions of good or bad conductivity e neglected, we fail to see how a change in the conductivity the earth can alter the lines of current flow in the slightest gree. Lines of current flow do not depend upon the disin- nation of the current to a high current density ; the current es not spread out in curved paths because there is no room it in a narrow one, but because of the mutual repulsion. r. Preece's views are, perhaps, to be accounted for in practice the want of homogeneity of the earth. In a poorly conduct- g soil the currents, finding a difficulty in returning, seek ths of lower resistance, even though they may be obliged to ɛe circuitous routes. In water the currents would follow the rmal paths. In sea-water Mr. Preece finds that with primary rrents of 15 amperes, effects have been traced to one-third of nile. In the absence of any information as to the distance tween the points of entry and exit this tells us nothing.

"It is very necessary," says the author, "to be able to dis- ıguish or separate these earth currents from currents due to luction, for they are very apt to give false effects and to lead erroneous conclusions. This is easily done, if the instru- ɛnt be sensitive enough, by making the primary current con- ıuous when the earth current also becomes continuous, while luction currents are momentary, and are observed only ring the rapid rise or fall of the inducing cause."

This introduction is followed by some elementary considera- ɔns of electrostatic induction, allusion to Faraday's idea of e nature of electric current, and to the hypothesis of Max- ll and Poynting. "The truth," Mr. Preece remarks with ution, "lies probably in a combination of each view." A ries of experiments of a very simple character, but conducted a very large scale, are then described. "Conductors of pper wire, insulated with gutta-percha, were formed into ıarter mile squares, and laid on a level plain at a distance a quarter of a mile apart. Arrangements were made r sending vibratory or alternating currents, which would broken into Morse signals by means of a telegraph y. Telephones were used as receivers." Signals could, of urse, be transmitted. So far, the experiment is plain enough, t we fail to make much of the next paragraph. "Next, order to ascertain to what extent, if any, electrostatic effects ere observable, one pole of the battery used was put to earth, d the further end of each square was disconnected. Now, this arrangement, the mean electric force of one square was ubled, as compared with the former experiment, where the cuit was completed ; but no effect was observed in the second ıare, either in the receiving telephone or with the reflecting lvanometer." If an alternator were used instead of a battery, d if "mean electric force" is intended for average difference potential between the squares the proof would be satis- tory.

Several cases of induction between straight wires and ıares are considered, some of them being of so obvious a character as to be hardly worth recording. The rela- tions between the length and distance of the wires are con- sidered ; but the wires of "finite length" appear to have been put to earth at each end. It is confessed that "the reverse effect of the return circuit through the earth" ought to be allowed for ; but after this admission has been made, earth currents are practically ignored in the remainder of the Paper. Some of the formulæ are inexplicable, unless they are intended for very rough approximations of extreme values. With two squares, for example, of equal dimensions lying in the same plane, the inductive effect is said to vary directly as the length of one side, and inversely as the square root of their distance apart, when this distance is short compared with the length of the side ; but as soon as the distance exceeds half the length, Mr. Preece informs us that it suddenly jumps to another value, viz., directly as the length and inversely as the distance. Of course, when the distance is "very great the effect would diminish, and ultimately disappear, owing to the opposing current in the back of the square having practically the same influence as that in the front."

The experiments between Flatholm and the coast of South Wales ought to have been of great interest, but after reading them with care we cannot think that the whole of the ob- served effects were due to induction as Mr. Preece suggests. At Lavernock Point, near Cardiff, two thick copper wires were suspended on poles for a distance of 1,267 yards, the ends were earthed, and an alternator driven by a 2-H.P. steam engine sent a current of any desirable strength up to a maximum of 15 amperes at 192 ∾ through the circuit. The current was broken up into Morse signals by a suitable key. On Flatholm, 3·1 miles away, an insulated wire was laid for a length of 600 yards ; the ends, we suppose, were earthed, and the circuit included a telephone. From the illustrations which appear in the New York electrical journals it seems that the wire on the main land is inclined at an angle of about 60deg. to the direction of Flatholm. There was no difficulty in communicating between the two circuits. At Steepholm, an island 5·35 distant, and in a direction at right angles to the "primary circuit," the signals were percep- tible, but conversation was impossible. A small steam launch was used to drag half a mile of gutta-percha-covered wire up and down between the primary circuit and the islands. The end was attached to a buoy, but, we presume, was not insulated, but was left bare at the buoy end and earthed to the tug through a telephone. As long as the wire was near the sur- face signals were heard, but when it was allowed to sink in deep water no effect was perceptible. In this way, says Mr. Preece, it was possible to trace without any difficulty the region where the lines of current flow ceased to be perceptible as earth currents, and where they commenced to be solely due to electro- magnetic waves. "The total absence of sound in the sub- merged cable," he writes, "rather surprised me, and it leads to the conclusion, either that the electromagnetic waves of energy are dissipated in the sea-water, which is a conductor, or else, that they are reflected away from the surface of the water like rays of light." This experiment is interesting, but the expla- nation is not convincing. The currents set up by the electro- magnetic waves would be opposed to the earth currents, which Mr. Preece ignores. While at the surface the wire would be fully exposed to induction effects, but as it sank it would more and more tend to pick up the earth currents, and the two effects would neutralise each other. The general practical conclusion arrived at in the Paper is that signalling would be possible be- tween two wires, each 10 miles long and 10 miles apart, no mention being made of the necessary current. Mr. Preece concludes by pointing out that "as these waves are transmitted by the ether they are independent of day or night, of fog, or snow, or rain, and, therefore, if by any means a lighthouse can flash its indi- cating signals by electromagnetic disturbances through space, ships could find out their positions in spite of darkness and of weather. Fog would lose one of its terrors, and electricity becomes a great life-saving agency." It is not difficult to throw out such a suggestion. We did so, in fact, in a Note some two and a-half years ago. But it does not seem that these elaborate experiments make any appreciable advance towards its realisation.

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It is of practical interest, and possibly, of practical importance, to transmit signals as Mr. Preece has done over a distance of several miles. Having done this, it would be of scientific interest to learn whether the signals were due to earth currents or to electromagnetic radiation. Evidence to show the nature of the signals, and for which we have been waiting for nearly a twelvemonth, is not to be found in Mr. Preece's Paper. We have assumed that the ends of the "secondary" wires were earthed, if they were sealed up and insulated, a telephone being used instead of the spark-gap of a Hertz resonator, our objections fall to the ground. It would be easy to prove the non-existence of earth currents. In one place Mr. Preece admits this, but on the whole he ignores them. A continuous current in the primary, and an interruptor with a telephone in the secondary would give signals due only to earth currents, exactly as the ringing of electric bells near the City and South London Railway. The effects would, no doubt, be improved by immersing earth plates in the sea instead of burying them on land. Luminiferous ether, and all that sort of thing, would unfortunately be eliminated. To secure purely inductive effects would be more difficult, and the advantage of using them is not very evident. A telephone instead of a spark-gap on a straight insulated line does not seem very promising, and the only way would be to use the pairs of squares referred to in the earlier part of the Paper.

But Mr. Preece seemed to make rather too modest a claim when, in the course of a brief discussion after the reading of his Paper at Chicago, he said that he would not expect a ship to get a communication from a greater distance than the length of a ship. This is, indeed, sticking to the ether theory, for we thought it had already been accomplished by earth currents.

Regarding Flatholm as a ship 600 yards long, it has been found possible to communicate with it from a distance of about nine times its own length, this distance being about four and a-quarter times the length of the primary circuit, or five times its projected length. Mr. Preece, we are glad to learn, intends to investigate the flow of earth currents. In doing so we hope that he will be enabled both to develop these interesting and perhaps important methods of signalling without wires, and add to our knowledge of the behaviour of the earth as a conductor. The old idea of the earth as a vast reservoir or sink or body of zero potential served excellently for early telegraphic work, but its use as a return conductor for purposes of electric traction compels us to acknowledge the existence of return currents, and any light that can be thrown upon them will be of undoubted practical value.

INTERNATIONAL ELECTRICAL CONGRESS AT CHICAGO.

A full account of this Congress, together with several of the Papers in full, abstracts of others, and reports of many discussions, appeared in the *Electrical World* of New York for September 2nd. From this account we have prepared the following abstract:—

The Electrical Congress at Chicago was "called to order" on August 21st by Prof. Elisha Gray, who delivered an address of welcome. An organisation committee was appointed to elect officers, and during its sitting Prof. Ayrton gave a short address on American electrical engineering and on the Exhibition from a stranger's point of view. The display of electric lighting and tramways filled him with admiration, and he felt pleased to know that they had no Board of Trade to control their affairs, but the mode of constructing their tramways, the telephone, telegraph, and high-pressure electric light wires jumbled up on the same posts, sometimes with the insulation a little defective, reconciled him to the dominion of Whitehall; and he took comfort in the thought that high-pressure transformers in his own country were not stuck like flies on the house walls. Looking at the Exhibition even from a purely American standpoint, he did not think that the exhibits inside quite did justice to the country. There was no model or plan of the Niagara scheme, while at Frankfort they really saw the thing done. At Frankfort it was what was inside the electrical building that dazzled his mind; at Jackson Park it was what was outside the Electricity Building that rivetted his attention. Prof. von Helmholtz was elected President, and made a short speech, being followed by Prof. Gray, Mr. Preece, and Prof. Mascart. The Congress then adjourned until the next day.

On Tuesday, 22nd, Section A, devoted to pure theory, met with Prof. Rowland as Chairman, but no blackboard having been provided, the meeting adjourned.

On Wednesday, 23rd, Prof. A. Macfarlane, of the University of Texas, read a Paper on "The Analytical Treatment of Alternating Currents," in which he described what was meant by natural analysis, and criticised the graphical method of Bedell and Crehore as not being applicable to complex cases. The purpose of the Paper was to show that not only the applications, but also the fundamental principles, are obtained by plane algebra, which he defined as the algebra of complex quantities. The next Paper was by Mr. C. P. Steinmetz on "Complex Quantities and their Application in Electrical Engineering." This Paper contained a novel method of the treatment of alternating currents, which simplified methods involving complex quantities, by supplanting all periodic functions and trigonometric functions with constant quantities of simple algebraic expressions. The device is to introduce the letter j in the expression of the sine curve, at first simply as a distinguishing index without mathematical meaning, and afterward as $j = \sqrt{-1}$. Complex quantities can then be treated as simple quantities, and only a knowledge of algebra is necessary to handle them.

The next Paper was by Drs. Bedell and Crehore on "The General Discussion of the Current Flow in Two Mutually-Related Circuits Containing Capacity." This Paper was a continuation of one presented at the general meeting of the American Institution of Electrical Engineers at Chicago, June 7, 1892, in which the authors considered the problem of finding the current which flows in a single circuit having resistance, self-induction, and capacity in series, with a low frequency and low magnetisation, and when no iron is present. Throughout the Paper, the reading of which was continued on the next day, the coefficients of self-induction were assumed as constant, not taking into consideration, therefore, the changes in self-induction, magnetic leakage, or, indeed, the presence of iron.

On Tuesday, Dr. Johann Sahulka, delegate, Technische Hochschule Vienna, next read a Paper on "The explanation of the Ferranti Phenomenon," in which he endeavoured to show that the "Ferranti Phenomenon" was based upon the magnetic leakage of the transformer.

The Papers for the last day were: "Measuring the Power of Polyphase Currents," by A. Blondel; and "The Extended Use of the Name Resistance in Alternating Current Problems," by Prof. W. E. Ayrton, but owing to the absence of the authors they were "read by title." The section was adjourned *sine die*.

Section B dealt with Theory and Practice. Prof. Cross was elected Chairman. The first Paper was that by Mr. Preece on "The Transmission of Electrical Signals Through Space."

In the discussion, Mr. Lockwood described somewhat similar experiments made many years ago by Morse and others. Mr. A. W. Heaviside described an interesting case, in which communication was found possible from an underground mine to the surface, without any direct connection. Mr. Lemp suggested that the area of loop in electromagnetic induction signalling might be of importance.

The second Paper was on "Ocean Telephony," by Prof. Silvanus P. Thompson. The Paper was greatly appreciated by the members, as was shown by prolonged applause; the discussion was postponed until the next day.

A large portion of the second day was devoted to the postponed discussion of Dr. Thompson's Paper. Prof. Jamieson estimated that the cost of such a cable would be about three times as great as that of the one in ordinary use at the present time, and that it would be difficult to locate faults. Mr. Kennelly called attention to the fact that it might be balanced for one particular frequency, and for one only, but that with the distortionless circuit proposed by Mr. Lodge the line might be balanced for all frequencies. Mr. Alex. Siemens, Mr. A. W. Heaviside Prof. Cross, and others also contributed

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me interesting remarks to the discussion; in general the ea was favourably commented upon, but it was shown that fficulties arose, which, however, were probably not insur-ountable.

The next Paper was that of Dr. Lindeck on "The Best aterials for *Resistance* Coils." It was a very careful summary data collected from various sources, principally from the eichsanstalt. A Paper by Mr. Kennelly on "The Temperature efficient of Copper" was then read. In Prof. Thomas's aper on "Photometric Measurements," which followed, spoke of the apparent errors which have been noticed the law of the inverse squares, and showed that one source error was due to the reflection from the inside of the glass ylindrical chimney or spherical bulb of the lights.

On the third day Prof. Carhart read a Paper on "Electrostatic oltmeters." These instruments combined the electrometer rinciple with that of the torsion head, and were, therefore, zero eading instruments. The next Paper was that of Prof. Tebster on "A Method of Governing an Electric Motor for hronographic Purposes." He uses a tuning fork to obtain bsolutely constant pulsations of the current, the motor being synchronous one. Prof. Ewing's Paper on "Iron for Trans-rmers" was read by the Secretary, Prof. Ewing not being resent. In general he laid great stress on hysteresis losses nd less on high permeability. Prof. Jamieson read a Paper n "London Electrical Engineering Laboratories," Dr. Bedell on "Transformer Diagrams Experimentally Determined," and Mr. ennelly on "An Improved Instrument for Measuring Mag-etic Reluctance."

The sitting of the fourth day, which was devoted entirely to he subject of arc lights, was opened with Prof. Ayrton's Paper n "The Variation of the Potential Difference of the Arc ith Current, Size of Carbons and Distance Apart." In it he ave the results of a very complete set of tests made with c lamps. M. Violle read a Paper in French on the bject of "Light and Heat of the Arc." The next Paper, at of Prof. S. P. Thompson, on "The Swinburne-hompson Unit of Light," was read by title at the sug-estion of the author. In Prof. B. F. Thomas's Paper on "The eriodic Variation of the Candle-Power of Alternating Arc ights," which followed, he gave the results of measurements the arc at successive points of the current wave, showing me interesting features, one of which was that the intensity the light followed instantly any changes in the current. rof. Carhart read his Paper on "The Maximum Efficiency of rc Lamps with Constant Number of Watts" in abstract only, the matter was included, to some extent, at least, in Prof. yrton's exhaustive Paper. The meeting closed with the read-g by title of two Papers in French by M. Blondel, one on New Researches with the Alternating Current Arc," another n "The Constant Current Arc and its Employment as a tandard of Light," and the last by Prof. Rowland on "The ource and Effects of Harmonics."

Section C, of which Prof. Houston was elected chairman, was evoted to "Pure Practice." On Tuesday Prof. Houston made brief introductory address, in which he called attention to the ct that while the Congress had been divided into three sections, o difference in reality existed between the various parts. The reat advantage would come from the intercourse of the repre-entative men of different nationalities, and it might seem as if would have been better if no division or a division along dif-rent lines had been made. Mr. F. Shulze-Berge read a Paper n "Rotary Mercurial Air-Pumps." Mr. Shulze-Berge and his rother have devised a form of pump which consists of a ollow ring of steel, about one metre in diameter. This revolves bout an axis, one end terminating in a stuffing box. The ollow ring is partly filled with mercury, and connected by a ree-way cock and tube to the axis.

On the second day Prof. D. C. Jackson read a Paper on Underground Electric Construction in the United States." rof. Jackson described four kinds of subways now more or ss in general use in the United States, viz., those constructed : (1) Iron; (2) sheet iron laid in cement; (3) clay or terra-tta; and (4) wood. Mr. F. Sahulka read a Paper on "The arious Uses of the Electrostatic Voltmeter." Prof. L. B. larks read a Paper on "The New Incandescent Arc Light."

The meeting on the third day was opened by a Paper "On Direct-Current Dynamos of Very High Pontential," by Prof. F. B. Crocker, of Columbia College. After stating that by very high potentials he meant potentials from 5,000 to 11,000 volts, Prof. Crocker pointed out the essential features of such construction, and proceeded to a description of two machines built by him, one of 1 H.P., with a potential of 5,000 volts and only 32 commutator bars, and the other of about 11,000 volts, at 1,800 revolutions per minute and 108 commutator bars. The current in this machine was, of course, small, not exceeding 4 amperes.

Dr. Louis Duncan, of John Hopkins University, was then asked to open the discussion on "Multiphase Motors and the Transmission of Power." He explained why the alternating-current motor, leaving out of consideration self-induction, had a higher efficiency than the continuous-current machine on account of the better distribution of the E.M.F. Starting an alternating-current motor was the great difficulty. This could be done, of course, but often with the consumption of a large amount of energy, and at the expense of everything else on the same line. Mr. M. F. C. Hasson, in giving the history of the transmission of power by electricity in California, said that so far it had been a failure, at least from the standpoint of the investor. Dr. Louis Bell considered the three methods of transmission: (*a*) By high potential currents; (*b*) by single-phase alternating currents; (*c*) by polyphase alternating currents. Prof. S. P. Thompson, at the request of M. Thury, mentioned a number of direct-current high potential plants in Europe where large horse-powers were very successfully distributed. Prof. Thompson gave further instances in which direct current distribution at high potential had been tried. Prof. Geo. Forbes, gave his views of the advantages of the various systems. He favoured the two phase system with two independent circuits, and had recommended this for the plant at Niagara. Mr. C. P. Steinmetz closed the discussion, saying that justice compelled him to defend the direct current, although he was most interested in alternating-current work. He thought the single-phase system was the system of the future.

On the fourth day Dr. C. Pollak then made some remarks concerning the device for converting alternating into continuous currents. Prof. George Forbes then continued the discussion upon multiphase motors and the transmission of power, which was opened by Dr. Louis Duncan at the session of Thursday. Prof. Forbes stated that all the great firms of the world had been asked for plans for the transmission of power from Niagara Falls to Buffalo, and that the bids for continuous-current system were much larger than any of the others. They had decided upon the same system of transmission for short and long distances. He thought a single device for transforming alternating to continuous currents full of great possibilities for the future, and that alternating-current arc lamps might come into general use before many years. He then briefly touched upon the question of the step-up transformer. Prof. H. A. Rowland differed with Prof. Forbes in that he favoured the use of step-up transformers instead of very high potential dynamos. He then took up the question of frequency, discussing its higher and lower limits.

On the afternoon of Friday, 25th, all the sections met as a General Congress. On the platform were the official representatives of the various Governments who had been in conference in the Chamber of Delegates. The report of that body on electrical units was read, and votes of thanks and speeches from Prof. von Helmholtz, M. Mascart, Mr. Preece, and Prof. Gray brought the Congress to a close.

Paper Belts.—According to the Boston *Commercial Gazette*, manufacturers will find that paper belting will replace that made from leather with advantage. Rubber and cotton have already been tried as substitutes for this purpose, but a belt made of paper is found superior to these, as it becomes covered with a hard shining surface in working, which makes the belt very durable. In making the belts, links made from strong paper pulp are used, and after working for some time, the coating of the belt next to the pulley becomes so hard that it can only be cut with the chisel.

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Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.

Editorial, Publishing, and Printing Offices :

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.

Telephone No. 2714. *Telegrams :* "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed "Coutts and Co."*

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All letters intended for insertion in "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as evidence of good faith. No notice whatever will be taken of anonymous communications.*

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THE CHICAGO CONGRESS.

The Electrical Congress at Chicago appears to have been the only feature of the Chicago Exhibition that has passed off without a hitch, and, judging from the reports that have reached us up to the present, it may be accounted a success. Elsewhere in our present issue will be found an abstract of a report of the proceedings, and the text of the report on electrical units. In an early number we hope to give our readers a summary of the Congress from the pen of one who was present. We recently reviewed the constitution and the results of the former international electrical congresses. At most of these, and we may reckon among them the conference at Edinburgh during the last meeting of the British Association, some real progress was made and important resolutions were carried. Some of these resolutions, such as that naming the "quadrant," have been superseded, and others, such as that dealing with the 106 centimetre ohm, were only of a temporary character. No important steps were expected of the International Congress, for its unfortunate association with an International Exhibition placed it at a considerable disadvantage. It succeeded, however, in attracting a sufficient number of good men to make a show on the platform, and by carefully avoiding controversial points, and solemnly adopting a set of units which, Congress or no Congress, have been accepted by the civilised world, it saved itself from being ridiculous. The question of a unit of light, as must be apparent to all those who have paid attention to it, is quite unripe for decision. The arc standard, on which several experimenters are at work, even though it may turn out to be a practical and trustworthy standard, is in no sense a unit. The other matter which the Congress put aside, the system of symbols and notation suggested by M. HOSPITALIER, may or

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may not be ready for universal use, but the Congress was far from strong enough to carry it, even if the system were beyond criticism. To attempt to increase the unit of current tenfold, making a new ampere equal to the C.G.S. unit of current, was quite out of the question at a gathering of this kind. The adoption of the henry, and the public and international ratification of the labours of the Board of Trade Electrical Standards Committee and of the Edinburgh Conference will, however, remain a justification for the holding of the Chicago Congress.

We have recently remarked that the reading and discussion of Papers has no obvious connection with a Congress which is summoned to consider and pass resolutions of International importance. The only advantage of such a combination is that by intercourse of representative men of different nationalities, useful discussion may be elicited. The discussions, judging by the reports in the American electrical journals, did not, however, rise above the desultory conversations of a sectional meeting of the British Association. A discussion pure and simple, with no Paper as a text, might yield most valuable results if carefully managed. The subject ought to be announced months beforehand, the speeches arranged as for an important debate. An attempt was made in this direction by a discussion on "Multiphase Motors and Transmission of Power." Nothing new was disclosed, but there were as many views as speakers.

Turning from the discussions which can alone be the excuse for communicating Papers to such a gathering, to the Papers themselves, we find that some were only "read by title," and others were not printed; they appear, on the whole, to have been of the usual British Association character. The most important communications seem to have been that of Prof. S. P. Thompson on ocean telephony, of Prof. Ayrton on arc lamps, and of Mr. Preece on telegraphy without wires. The first of these we have already published; the second is, we understand, very long and elaborate, but we hope to give an abstract of it; the third is discussed elsewhere in our present issue. Prof. Marks's enclosed arc light was described in our columns last week. The Papers by Dr. Lindeck, Prof. Ewing, and Prof. Rowland are sure to be worth studying, but descriptions of a chronograph device, and of a mercurial pump, seem to be quite out of place at an international congress. The novelty of Mr. Steinmetz's mathematical device is not very apparent, but if his Paper contains anything which will really simplify complex expressions it will be welcome. The mathematics of Drs. Bedell and Crehore promised at one time to be very attractive, employing as they did graphical methods and appearing to deal with practical problems, but their last effort is very disappointing; few electricians and fewer electrical engineers will trouble themselves about analytical work in which the presence of iron is ignored. To one Paper, which has appeared in the *Electrical World* of New York, we record our strong objection elsewhere. The holiday nature of this part of the Congress is apparent enough in the comparative unimportance of some of the Papers. If strict rules had been made for the reception of Papers a month or so before the opening, for their examination by a small and strong committee, and for the printing and distribution of the accepted Papers before reading, it would have been unnecessary to divide the Congress into three sections. But what holiday meeting is strong enough to attempt this, and outside two or three scientific societies, where is it done? We hope that our special account of the Congress will disclose some new features of interest, and that the Chicago Congress of 1893 may prove to have achieved something more stirring than a mere ratification of previous conclusions.

REVIEWS.

Scientific and Technical Papers of Werner von Siemens. Vol. I., Scientific Papers and Addresses. Translated from the Second German Edition. (London: John Murray.)

The great strides that have been made within the last thirty years or so in the science of electricity and in its applications, cannot be adequately realised by the student of to-day unless he has made himself acquainted with the difficulties, investigations, and theories of the founders of modern electrical science. An assured, but certainly a somewhat laborious way of attaining this knowledge is to read the collected Papers of men like Werner Siemens. These Papers, while they cannot compare from the point of view of lucid exposition and unity of purpose with the classic experimental researches of Faraday, present, nevertheless, numerous points of practical and scientific interest, and cover a wide field, ranging from details of telegraph construction and operation to investigations on electric resistance, static induction, and theories of solar and meteorological phenomena. In a Paper published in Poggendorff's Annalen, in 1850, Werner Siemens has much to say about the advantages of the then novel bell-shaped telegraph insulators, and about the difficulties caused by lightning and static charges on long telegraph lines; "hardly a summer passes with a long overhead line that the lightning does not strike it, damaging the instruments, and partly destroying the line." In the same year, a long memoir, presented to the Académie des Sciences described certain curious phenomena observed on long underground lines, reasons being given for thinking they were due to electrostatic induction and not to "secondary polarities" developed in the wires. Earth currents are also alluded to, and their generation attributed to variations in the magnetism of the earth. In 1857 Werner Siemens published a Paper in Poggendorff's Annalen on "Electrostatic Induction and Retardation of the Current in Cores." This contribution, which occupies no less than fifty pages of the present volume, is largely devoted to accounts of experiments made with a view to test Faraday's "contiguous particle" theory of electrostatic induction, and contains a passing reference to the electrolysis of glass. The conclusion drawn from numerous experiments is "that it is very likely that the seat of the electricity is removed from the conductors to the non-conductors surrounding them, and may be defined as an electrical polarisation of the molecules of the latter. The conductors would then only be conceived as polarised spaces in an electrically polarised medium, with the property of being able to carry over the polarisation in their medium from one point of their surface to another. If the specific inductive capacity of the conductor may be assumed as very great compared with that of the non-conductor and proportional to its conductivity, its induction maximum, on the other hand, as infinitely small, then all conditions for the explanation of the phenomena of the electric current and also its attraction and repulsion appear to be fulfilled." In 1875, Werner Siemens endeavoured to measure "the velocity of transmission of electricity in suspended wires," and obtained the figure of 256,600 kilometres a second. In 1880, the experiments of Matthiessen and Auerbach being contradictory on the important point of the increase of the conductivity of carbon with rise of temperature, Werner Siemens set to work to settle the question, and found that up to 900° C. the resistance of carbon continued to decrease, the conflicting results obtained by other observers being attributed entirely to defective end connections. We may conclude our notice with the following lively account of a scientific investigation carried out by Werner Siemens and a party of friends on the summit of the Cheops pyramid during the blowing of the "chamsins." Having reason to suspect electrification of the atmosphere, the party proceeded to investigate the matter. "After the Arabs had watched our proceedings for a time with wonder, they came to the conclusion that we were engaged in sorcery, and requested us to leave the pyramid. As their remarks, when interpreted to us, were without effect, they wanted to use the power of the

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strongest to remove us from the top by violence. I withdrew to the highest point and fully charged my strengthened flask, when the Arab leader caught hold of my hand and tried to drag me away from the position I had attained; at this critical moment I approached the top of my flask to within striking distance of the tip of his nose, which might be about 10mm. The action of the discharge exceeded my utmost expectation. The son of the desert, whose nerves had never before received such a shock, fell on the ground as though struck by lightning, rushed away with a loud howl, and vanished with a great spring from our vicinity, followed by the whole of his comrades."

Griffin's Electrical Price-Book. Edited by H. J. Dowsing. (London: Charles Griffin and Co. 1893.)

A book breaking fresh ground is not to be too critically judged, especially when it is one of a class which must necessarily pass through continual revision, if not regular annual editions. This price-book, edited by Mr. Dowsing, has many of the good points of Laxton and other well-known publications, but with these as guides something more might have been expected. The discussion of such matters as "Statutory Powers," "Selection of a Site for a Central Station," "Notes on Foundations for Machinery," "Digest of Board of Trade Regulations," &c., would be all very well in a general handbook, but they must be treated at sufficient length to allow some really useful information to be given. As introductions to different sections a single paragraph should be sufficient, a page or two of smattering is useless, except to smatterers. One of the very first lists is an example of the mechanical copying of a very old-fashioned price list of steam-engines—old-fashioned, not because the quotations are out of date, but because nominal horse-power is given without a hint of the brake, or even of the indicated horse-power. The price list of boilers described only by nominal horse-power is still more absurd. For the sake of uniformity the sizes of lubricators which are dotted about among these lists should have been given in nominal horse-power instead of in pints. Only three makes of steam engines are given. Gas engines are better done, but the cautious "approximate indicated horse-power" is in most cases given instead of brake horse-power. This is, of course, the editor's misfortune, not his fault. Messrs. Crompton and Co. naturally occupy the larger portion of the space devoted to dynamos, as well as of the other sections dealing with their manufactures. The "Westminster" and "Silvertown" dynamos are not quoted, nor are any Continental makes included.

Having recently searched the lists of most of the leading firms in vain for a 2 H.P. alternator, we were interested to find under "Dynamos-Alternating Current" a list of "'Heaton' Dynamos," by C. A. Parsons and Co., beginning with 1·2 kilowatts at 1,250 revolutions. But on closer examination, the prices for "machine shunt or compound," "spare commutator," and so on, suggests that these are continuous, current machines. The section on storage batteries is fairly complete, but the Drake and Gorham "D. P." accumulators are not mentioned. A considerable number of minor errors will, of course, disappear in future editions, such as the inclusion of Crompton's potentiometer and sundry other instruments under the manufactures of Goolden and Co.

Several makers of insulated cables and well-known arc lamps are omitted, and under the heading of "Warming and Cooking, &c.," no mention is made of the General Electric Company's goods. The expression electromotive force we have heard of, but rarely use; what is "Electromotive Power"? Nothing more than electrical transmission of power. Not a single alternate-current motor is offered—again no fault of the editor. After some table of statistics, a "specimen" report by Mr. Preece on the lighting of "A Provincial Town," and another, with estimates by Mr. Crompton, are given. Some very poor sample specifications follow, and a few very vague estimates, wiring and fire insurance rules, a few memoranda and tables, and a rather careless index, conclude this very well-intentioned, but rather disappointing book. The compilation of such a work is necessarily very laborious, and the first issue naturally fails to be perfect. We have said enough to show that with all its short comings it contains a great deal of information which can only be obtained by searching through files of catalogues—a most tiresome proceeding; and it may be expected that future editions will prove to be most useful in several different branches of the electrical trade and profession.

Lightning Express Railway Service. By F. B. Behr.

Our readers who are interested in the problem of high-speed railway service, which has recently been discussed in our columns (see *The Electrician*, Vol. XXXI., p. 475), will find a considerable amount of food for reflection in the pamphlet before us. Mr. Behr attacks the problem in a manner which clearly shows that he is fully cognisant of the difficulties which envelop it; and, though we are not quite prepared to follow him to the full extent in regard to the system he advocates, we are quite in agreement with him where he shows the impracticability of adopting the existing railway systems to any very much more rapid service. In the first section of his book the author answers negatively the question—Are the ordinary existing lines suitable for speeds of 120 to 150 miles an hour? In the second section the general conditions of construction for high-speed service are discussed, in regard to the track, the rolling stock, and the working arrangements. The remainder of the work is devoted to an elaborate defence of the Lartigue single-rail system as the "only one satisfying all the requirements." This system has recently been adopted for a railway from Feurs to Panissières, in France, which is in process of construction; but the only instance, as far as we are aware, of an actual, extended trial of the system was on a length of 9½ miles of line between Listowel and Ballybunnion, in Ireland. In matters of engineering pioneer work, it has been proved over and over again that the only true criterion is actual practice. A scheme may appear excellent on paper; it may satisfy every engineering equation which tends to place an obstacle in the way of success. But it does not follow that the scheme will be either an engineering or a commercial success, when it shall have become endowed with living activity. Nine and a-half miles between Listowel and Ballybunnion will not suffice to demonstrate that any railway scheme, however plausible on paper, will be found suitable for lightning express trunk railway service.

THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 500.)

"Sealing-in" the filament is the next process to be described. The precise details of the process depend upon the way the filament is mounted, whether the platinum wires are joined together by glass in any way, and whether the lamp is to be "capped" or is to have the platinum wires formed into loops at the bottom or sides of the neck of the bulb. First of all, the exhausting tube, if closed up, must be opened by cutting off the tip. This tube is now used for holding the bulb, and it makes a very convenient handle by which to rotate the bulb in the flame. The neck of the bulb is then heated by rotating it in the blow-pipe flame, so as to soften the glass at a short distance from the bulb. When soft the superfluous piece of neck is pulled away with the right hand, while the left still holds the bulb in the flame, so that the piece of neck is severed from the rest, leaving the bulb with the short remaining neck closed up. If too long a neck still remains, more may be removed by again heating and drawing it off by means of a small piece of glass rod or a bit of waste glass from a former operation. The end of the short neck has now to be opened for the reception of the filament. It is again held in the flame, and when soft the small tube is blown through somewhat violently, so that a hole is blown or a large and very thin bulb

* Abstract from a book to be published shortly by *The Electrician* Printing and Publishing Company (Limited). All rights of republication reserved.

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is formed, which can easily be removed with the end of a file or other instrument, A, Fig. 29. The opening produced is probably too small to get the filament through, and it must therefore be enlarged. This is done by pressing out the sides when soft with the end of a file, as B. One of the glass blower's most useful tools is a small fine file, as with it he can scratch the glass in order to cut it at any point, while the end which is intended to go in a handle can be used for moulding the glass when soft. The filament already mounted on the platinum wires is next carefully inserted through the opening. It may be handled by the wires by means of a small pair of pliers. When far enough in the bulb the wires are held against the glass at the end of the opening and held in the flame. As soon as the glass at the point of contact is soft, the wires will adhere to it, and the pliers can be laid down. The next thing is to close up the opening. It will close up of itself if sufficiently heated, but it may be assisted by pinching with a pair of spring nippers made for the purpose. If this is done there will be rather large corners formed, as in C, which can be cut off while soft with a pair of cutting nippers. To make the seal good and neat it will require several times heating and blowing out by blowing through the small tube.

If the lamp is to be "capped," the end must be formed so that the plaster used in the cap will have a good hold on the lamp. It must be shaped so that it can neither be pulled out of the plaster nor twisted round in it. The simplest way of insuring this is to make a flat piece in the way just described with a thickened end, as in D, E. The flat end prevents the lamp from turning round, and the thickened part is surrounded by the plaster and cannot be pulled out. The

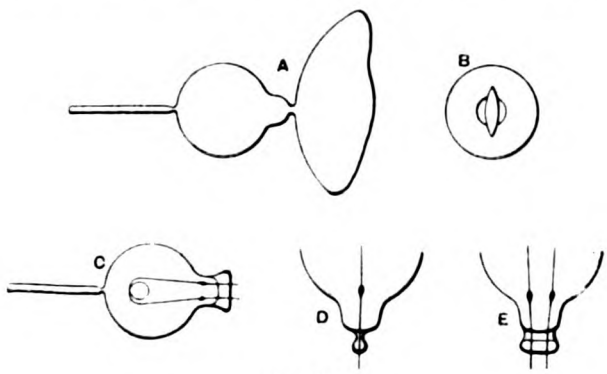

Fig. 29.

thickened end may be made by melting a piece of glass rod, and winding a string of the semi-fluid glass round the end of the flat piece. Or, if the glass in the neck of the bulb be thick enough, it may be simply squeezed upon the wires, but squeezed thinner close to the bulb than at the end where the wires come through.

Some glass-blowers adopt a somewhat different method of sealing in. The filament is inserted in the opening in the bulb, as before, but is allowed to slip inside, wires and all. The neck is then heated, and drawn down quite small, and sealed up. A small hole is then made in the end by blowing through as before. The bulb is tipped up so that the wires protrude by the required amount. The small opening is then easily closed up as before. This is rather a neater method than the other, but is more likely to injure the filament. If the wires are to be formed into loops, they may be bent into shape before the filament is put into the bulb, or the loops may be formed after the seal is made. The first method produces the most uniform loops. Care must be taken in forming the loops that they are of equal size, or there may be a difficulty in making contact with the holder to which the lamp will eventually be attached. If the wires are to be brought out at the sides of the neck, a similar method may be used, the filament being inserted as before, and the ends of the wires pushed back through small holes made in the neck. Another method is to cut the neck off at the place where the wires are required to come out, and then to put in the filament with the wires reaching over the sides, and melt the neck on again.

The filament having been sealed into the bulb, the next process is that of exhausting the air. This process is, perhaps, the most important of all, as upon the excellence of the vacuum produced depends, to a very great extent, the life of the filament. It is, moreover, the most costly per lamp of any of the processes.

It is necessary that the air be removed from the bulb, primarily, on account of the combustible nature of the filament. If a carbon filament is heated to incandescence in air, by a current of electricity, it rapidly burns away. Even if the air is removed as far as possible by exhausting with a good mechanical air-pump, there will be sufficient left behind in the bulb to burn the filament enough to speedily cause its breakage. It is necessary to produce a very much better vacuum than can be obtained by any ordinary mechanical vacuum pump. A very small quantity of air left behind in the bulb will be enough to burn the filament slightly, and thereby shorten its life.

It has, at various times, been proposed to fill the bulb with nitrogen gas, and then to only partially exhaust. In this way a residual atmosphere of nitrogen could be left behind,

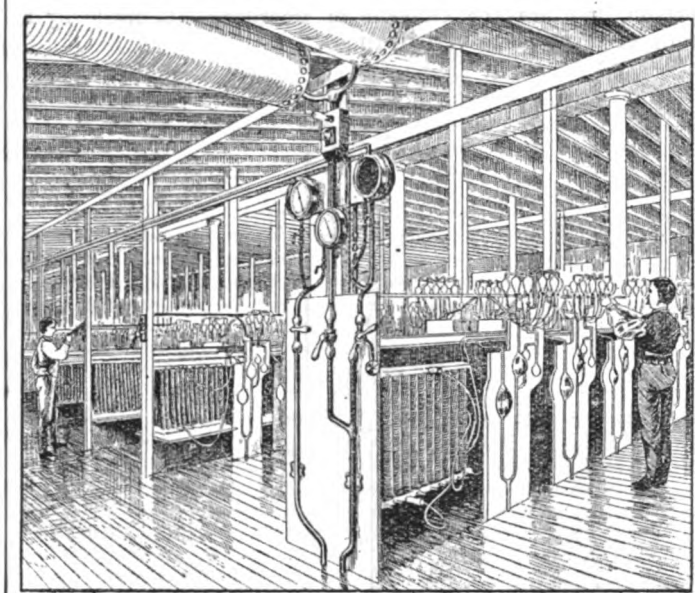

Fig. 30.—Sawyer-Mann Pump Room.

which would be incapable of burning the filament. Another advantage of the method would be that the exhaustion, not requiring to be carried to a very high state, could be done very quickly with a mechanical air-pump.

When the vacuum is not good, and there are consequently convection currents set up within the bulb, the law of $c \propto d^2$ does not appear to apply, or, at any rate, it becomes useless for the practical purpose of calculating the sizes of filaments. The actual amount of the effect of convection depends not only on the pressure of the gas but on the size of the bulb. If the bulb is small, the gas within it will get much hotter, and the filament will also be hotter than if the bulb is large, when there is a greater quantity of gas to be heated and a larger surface of glass for it to cool against. It therefore becomes necessary that the vacuum in a lamp shall be so far perfect that convection currents are absent altogether. In order to produce such a vacuum it is necessary to use what are known as mercurial air-pumps, mechanical air-pumps not being good enough for the purpose. Of course, it is impossible to obtain a theoretically perfect vacuum, but with the mercurial air-pump such a degree of exhaustion can be produced as to reduce the pressure of the gas to something unmeasureable, and to entirely remove all signs of convection.

The mercurial air-pump, although only within the last few years brought to a state of efficiency—it cannot yet be called perfection—is by no means a recent invention. It was used more than two hundred years ago. In the seventeenth century, Torricelli showed how a vacuum could be produced by filling a tube, something over 30in. long and closed at one

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end, with mercury and then inverting it, while temporarily closing the open end, and placing that end under the surface of mercury contained in a cup. The mercury in the tube then descended until it stood at what is now called the "barometrical height" above the level of the mercury in the cup. The enclosed space within the tube above the top of the mercury contained, therefore, a vacuum, as in an ordinary barometer. A vacuum so produced is always now called a "Torricellian" vacuum.

Progress from that time was slow. It was not until 1865, when Sprengel brought out his well-known form of pump, that high vacua were easily obtained, although, ten years previously, Geissler had invented the pump which is called by his name, and which, in a modified and improved form, is now found to be equal, if not superior, to the Sprengel pump.

Anyone who wishes for full information on the development of the mercurial air-pump from the time of Torricelli, must study the lectures delivered in 1887, before the Society of Arts, by Prof. S. P. Thompson. A reprint of these lectures, from the *Journal* of that Society, is published by Spon. Anyone reading these lectures will understand that the modern forms of pumps are in no case the invention of any individual person, but are the outcome of improvements made by a number of people at various times.

FIG. 31.

The illustration (Fig. 30) gives a view of the pump-room of the Sawyer-Mann lamp factory in New York, reproduced from the New York *Electrical Review*.

For factory use, Mr. Swinburne used the arrangement shown in Fig. 31. The shaft B passes through a rubber cork L, into the bottle M, to within a very little of the bottom. A tube, N, also passes through the rubber cork. In starting the pump the cock O is turned, thereby connecting the pump with the mechanical vacuum pump. Air is therefore drawn out of the pump and the lamps, and mercury from the bottle M rises in the shaft B until it forms a column nearly 30in. high, reaching to a point a little below the junction of the tube G with the shaft B. Air under pressure is then admitted at N. The mercury is consequently forced from M up the shaft B, filling the bulbs A and F, until it reaches the valve chamber K, driving the air before it. At this point, the full air pressure being exerted, the mercury rises no higher. The air pressure required is not great, only about 6lb. or 7lb. to the square inch, representing a rise of the mercury column from G to K of 12in. or 14in. By an automatic arrangement, the pressure is then taken off, the tube N being connected with the outside air. The mercury consequently descends, the valve K closing and remaining sealed, with some mercury left behind in the valve chamber. The mercury drops to below G. The air left in the lamps therefore expands into A, and the operation is again repeated.

Fig. 32 gives a view of part of a pump-room, with this type of pump, erected by the author. The pumps are of a rather large size, containing nearly 30lb. of mercury each.

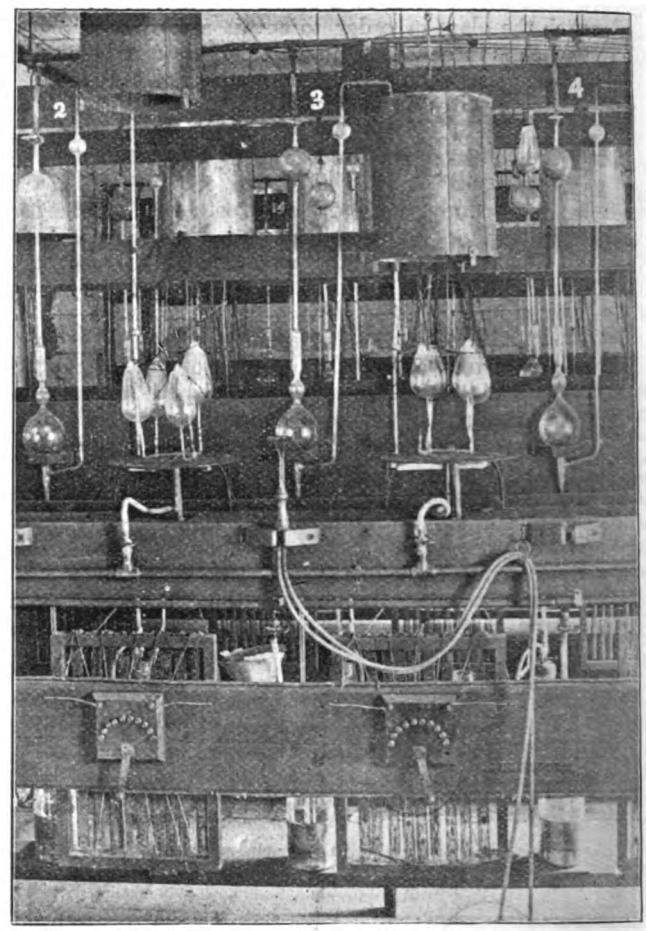

FIG. 32.

They differ from that shown in Fig. 31 in some of the details. For instance, instead of the rubber cork L in the reservoir M, the arrangement shown in Fig. 33 was adopted. A is a hard wood cap, fitting the top of the jar B, and having two metal tubes, C and D, passing through it. These tubes are

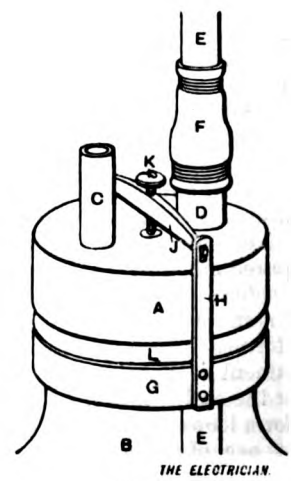

FIG. 33.

screwed in so as to be quite air-tight. E is the shaft of the pump, passing through D to the bottom of the jar B. F is a piece of rubber tube, bound tightly with wire round D and E, thereby making an air-tight joint. G is a metal collar round the neck of the jar, immediately under the rim L. H is an upright strip of metal fixed to G, there being another similar

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one on the farther side. J is a metal cross-bar, extending at each end into slots in the uprights H. K is a screw passing through J. A rubber washer is placed between the cap A and the top of the jar. The screw K is tightened until the cap is pressed down, so that the joint is air-tight. The air pressure pipe is connected to C. This arrangement was found to be much more reliable than the simple rubber cork, owing to the latter not unfrequently working loose and allowing the air to escape.

(To be continued.)

THE ELECTRICAL RESISTANCE OF METALS AND ALLOYS AT TEMPERATURES APPROACHING THE ABSOLUTE ZERO.

BY PROFS. J. DEWAR AND J. A. FLEMING.*

In the autumn of last year we published a short account of experiments made by us during the previous summer on the electrical resistance of metals, non-metals, and alloys taken at the temperatures produced by the evaporation of liquid oxygen when boiling under normal or under reduced pressures. These experiments, which were merely preliminary, revealed, however, the nature of the difficulties to be overcome in repeating and following out this work. During the past year a much more extended series of investigations have been carried out by us on the same subject, but with more complete appliances for the production of the large quantities of the liquid gases necessary as refrigerating agents, and with greater care in the preparation of the metallic wires used in the physical measurements to be made. This inquiry is still far from complete; but the results are of considerable interest as far as they have gone, and we consider it may be desirable to place on record a portion of the conclusions at which we have arrived. The general object of this research may be stated to be the determination of the specific electrical resistance of metals and alloys between the limits of temperature of about 200°C. and the lowest obtainable temperatures approaching the absolute zero. We particularly desired to investigate the variation of resistance with temperature below −100°C, and to determine the form of the temperature-resistance curves as the temperature is lowered down to the lowest points obtainable by the evaporation of liquid oxygen boiling under reduced or normal pressure. The two variables with which we are concerned being, therefore, specific electrical resistance and temperature, we may point out in the first place how each of these has been defined and measured in tabulating the results.

There are, as is well known, two ways in which we may define specific electrical resistance. The first, called the volume-specific resistance, is defined as the resistance of one cubic unit of the material taken between opposed faces of the cube. In this method of defining it the specific electrical resistance is given as the resistance in ohms, or electromagnetic units of one cubic centimetre of the material between opposed faces. The second, called the mass-specific resistance, is the resistance of a wire of the material of a certain length and weight. In this second method of defining it, it is generally stated as the resistance in ohms of a wire of the material one metre in length and weighing one gramme. When it is desired to compare together, or state the specific resistance of materials in the form of wires, of which the diameter is not very different from one millimetre or larger, and length, say, of one metre or more, there is no doubt that the most convenient way of stating the results is by means of the mass-specific resistance; and since the mean specific gravity of wires of this size can always be determined with a very fair degree of accuracy, the volume-specific resistance can easily be deduced. If, however, as in the case of our own experiments, the conditions necessitate the employment of very fine wires of about 0·08mm. to 0·25mm. in not very great lengths, the probable errors on determining the weight per metre, and especially the specific gravity, are very considerable. We therefore preferred to face the difficulty of determining the mean diameter of the wires employed, and state our results in terms of the volume-specific resistance. One part of the work consisted, therefore, in the determination of the mean cross section of a series of very fine wires prepared from the metals and alloys under test, taken by means of an optical method, to be presently described. From this mean cross section and the length, we are able to state, when the resistance is known, the volume-specific resistance of the material. Since, however, the measurements of length and diameter were all taken at temperatures between about 15°C. and 20°C., it will only be possible to express the true volume-specific resistance at any assigned temperature when we know the changes in dimensions which the material undergoes when heated or cooled. The true volume-specific resistance of the material at any temperature is the resistance in electromagnetic measure between opposed faces of one cubic centimetre of the material taken at that temperature. Pending, however, the determinations of the temperature-change in dimensions of the metals and alloys employed, we omit the correction (no doubt small) due to the change of dimensions, and state our results in terms of the electrical resistance in electromagnetic measure of one cubic centimetre of the material measured at 15°C., the said electrical resistance being determined at the various temperatures to which the material is raised or lowered. In the next place we have to consider the question of temperature-measurement. As the lowest temperatures reached by us in these experiments were temperatures at which air liquefies under ordinary pressures, the practical employment of the air-thermometer was surrounded with many difficulties. Ultimately it may be necessary to define the temperatures attained in terms of the absolute thermodynamic scale. But even the employment of the constant reduced-pressure hydrogen thermometer-scale, which may be taken as giving us the nearest practicable approximation to the true thermodynamic scale, is a matter in which extreme care will have to be employed in obtaining and interpreting results. We have been led, however, by one part of our results to see that, for our purpose here, by far the most practical method of defining the temperatures employed is to state them in terms of the variation of the specific resistance of one standard metal.

In the practical determination of temperature we select a thermometric substance, it may be air, hydrogen, mercury-in-glass, or some other material, such as a double metallic junction of thermoelectric materials, and we select also a thermometric quality, such as the change in pressure, change in apparent volume, or thermoelectric difference, and define our temperature by the temperature-change of the thermometric quality of this thermometric material. There is, therefore, nothing to prevent us from selecting as a measure of temperature the change in electrical resistance of a wire of a standard material and defining temperature in terms of the change. It will afterwards be possible to translate the temperatures so measured into their equivalents on the absolute thermodynamic or air-thermometer scales. Our experiments at low temperatures have confirmed us in the view that the most convenient method of determining and stating such temperatures is in terms of the change of specific resistance of pure platinum. H. L. Callendar and Callendar and Griffiths have carefully examined this matter for temperatures from about zero Centigrade upwards to about 1,000°C. Callendar has indicated the possible causes of the discrepancies in the results obtained by previous observers in the use of the platinum resistance-thermometer, as originally suggested by Siemens; and he has shown that a properly arranged pure platinum wire may be employed to measure temperatures, and may have its fixed points determined. We have in like manner found that a wire of pure soft annealed platinum may be cooled again and again to the lowest attainable temperatures, and heated up to high temperatures, without suffering any permanent change in its specific resistance after the first careful annealing has been made. This property is not, however, confined to pure platinum, but is equally possessed by other properly annealed metals. There are, of course, good reasons for giving preference to platinum in the construction of resistance-thermometers; but, on the other hand, it is possible that for low temperatures chemically pure nickel, prepared by the process discovered by Mr. Ludwig Mond from nickel carbonyl, will prove to be of great utility on account of its very large mean coefficient of variation of resistance with temperature. It is, however, clear that a wire of pure platinum which has been carefully annealed possesses a definite electrical resistance at each temperature to which it is exposed, and may be made use of as a thermometric body with great convenience. Callendar has introduced the useful term *platinum temperature* to denote temperatures measured with the platinum resistance-thermometer. On this scale the temperature is defined as follows:—Let R_0 be the electrical resistance of a given wire of pure platinum at zero Centigrade, that is when immersed in melting ice, and let R_{100} be the resistance of the same wire at 100°C. Then an increment of temperature, which causes a change in the resistance of the platinum equal to $\frac{R_1 - R_0}{100}$, is called one degree of platinum-temperature. If pt denote any temperature measured on this platinum-scale, and R be the resistance of the wire at that temperature, then

$$pt = \frac{R - R_0}{R_1 - R_0}\ 100.$$

Hence, if we take any straight line as a temperature-axis, and at any two points erect perpendiculars to it, which are proportional to the resistance of the platinum wire at 0°C. and 100°C., and draw through the summits of these ordinates a straight line cutting the axis of temperature, we may define temperature as follows:—Divide the horizontal interval between the ordinates into one

* Abstract from *Phil. Mag.*, September, 1893.

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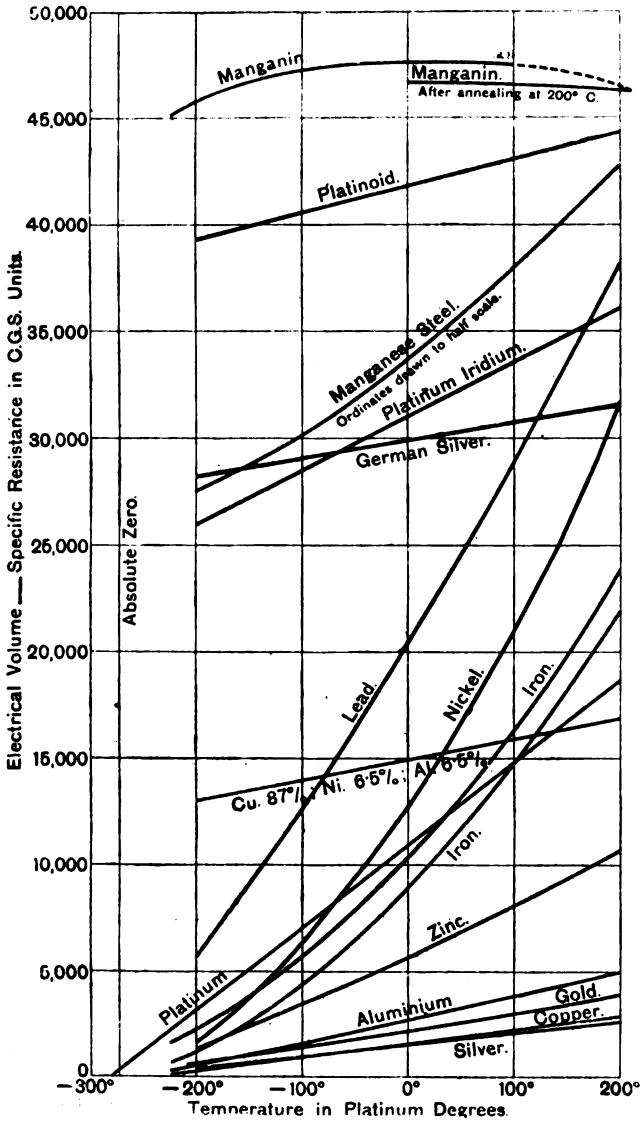
hundred equal parts, and continue the division on the scale backwards to the point at which the inclined line cuts the temperature-axis. Measure the resistance of the platinum at any temperature, and find the ordinate representing this resistance : the foot of this ordinate marks the temperature on the platinum-scale. Callendar has shown that the difference between temperatures measured on this platinum-scale and the corresponding air-thermometer temperature is very nearly represented by a parabolic function of the air-thermometer temperature. It remains to be seen if all pure platinum wires give the same platinum temperature. We have found slight differences between the specific resistance and temperature-coefficients of platinum wires of different diameters, prepared with the greatest care, and supposed to be equally pure, but which differences do, no doubt, depend upon slightly different degrees of hardness or purity. These differences are sufficient to make small but quite evident differences between the platinum



Variation of Electrical Resistance of Pure Metals and Alloys with Temperature.

temperatures as determined by these different platinum wires. These differences, however, are not more marked than would be the case with temperatures measured by different mercury-in-glass thermometers. We have accordingly selected one of our platinum wires as a standard thermometer, and have referred all our measurements of temperature to it, and subsequently we may determine the equivalent temperatures on the air-thermometer scale. This platinum wire we refer to subsequently as the "thick platinum" wire. In the chart appended to this Paper, the abscissæ of temperature are, therefore, platinum-temperatures as measured by our standard platinum wire. The general nature of the measurements made consisted, therefore, first, in the measurement of the length and mean diameter of a fine wire of a metal or alloy of carefully-prepared quality ; secondly, in the measurement of the resistance of this wire when immersed in a bath, giving it the necessary temperature ; and thirdly, the determination of this temperature of the bath by the measurement of the resistance of the standard platinum wire before and after the measurement of the given wire. From the results of these observations we could deduce the volume-specific resistance of the material at certain platinum temperatures, and plot a series of curves to represent the variation of this resistance with temperature.

Passing on to further details, we proceed to describe briefly the preparation of the metals and alloys in the required state of purity, and the construction of the resistance-coils suitable for the purpose of these experiments and the mode of making the required measurements. Our previous experiments had shown the necessity for the greatest care in the preparation of the metals. The term *pure* is, of course, a relative term, and absolute purity in a chemical sense is, of course, a most difficult matter to secure ; but every care has been taken to arrive at the greatest possible purity in the majority of the metals employed. In this part of the work we have been greatly aided by several friends. Foremost amongst these, we are especially indebted to Mr. George Matthey, who has given us invaluable aid in the preparation of a large series of metals in a state of great purity. Mr. J. W. Swan has furnished us with many samples of electrolytic copper and silver prepared by himself by his own special processes. From Mr. G. Addenbrooke we received samples of aluminium and aluminium alloys, which have been of use to us ; and Col. Dyer, of the Elswick Ordnance (Armstrong's) Works, has kindly sent us samples of iron prepared with very great care. Having these materials in our possession, they were in most cases drawn into wire for us by Messrs Johnson and Matthey, and in some cases, such as those of lead, tin, thallium, and some others, the metals were pressed into wire in a steel press by the hydraulic 50-ton testing-machine in the Mechanical Laboratory of University College, London. These different wires had a diameter varying from 0·08mm. (3 mils) up to about 0·25mm. (10 mils), and lengths of from 1 to 3 metres.

The next step consisted in measuring the mean diameters. For such fine wires no ordinary process of callipering was sufficiently accurate. After many experiments, the following method of obtaining rapidly the mean diameter was perfected :—A compound microscope had the eye-piece removed, and the substage under the object-glass fitted with a large cork, bored out in the centre with a hole, and having two small glass tubes inserted in the sides. This cork was so fixed to the stage that when a wire was drawn through the small tubes, it passed across the field of the objective. The stage had a rack-work motion, which enabled it to be moved to or from the objective ; but this last remained fixed relatively to the stand of the microscope. The microscope being placed horizontally, an incandescent lamp was placed behind a condenser lens at the back of the substage, and an image of the wire projected by the objective on to a sheet of fine hot-pressed drawing paper placed a yard away from the lens. The objective which formed this image always remained fixed relatively to the screen, and the image was focussed by moving the substage which carried the wire. The magnification of the image was about 300 times linear, so that the image of a wire about 0·003in. in diameter could be made to appear 1in. in diameter. A 2in., 1in., or ½in. objective could be used as desired. This optical image or shadow could be made exceedingly sharp and well defined, and could be measured with a pair of dividers to much less than 1 per cent. In order to infer the real diameter of the wire from the diameter of the image the following method was employed :—A series of five steel-wire gauges was made formed of round parallel steel wire about 10 centimetres in length, rammed into wooden handles. These handles were planed off on one side flat. These gauges varied in diameter from about 3mm. to 0·04mm. The gauges were sent to the Board of Trade Standardised Laboratory, and the diameters of the steel wires officially measured with their Standard instruments along axes parallel to the flat side of the handle, and taken at the centre of the wire. This being done, we had a series of standard gauges whose diameter in one definite position was known to the $\frac{1}{10000}$th of an inch. These gauges were marked A, B, C, D, E. Two more similar gauges were prepared, called F and G, of smaller steel wire, and a number of observations of the diameters of F and G relatively to E were made by means of a micrometer-microscope belonging to the Physical Laboratory of University College. Many observations were also made of the relative diameters of the images of gauges E, F, and G when projected by the projection microscope, the gauges being in the same focal position relatively to the objective and screen. These experiments, which were most carefully made, sufficed to establish the diameters of the steel gauges F and G in the centre and parallel to the flat side of their handles, in terms of the Board of Trade measuring instrument, and the final mean result expressed in centimetres, is that the central diameters of gauges F and G, parallel to the flat side of the handle, are as follows :—

Central diameter of gauge F = 0·03966 of a centimetre,
Central diameter of gauge G = 0·03959 of a centimetre,

taken at about the normal temperature 15°C. The process of measuring the mean diameter of any wire was then as follows :—The

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Table I.—*Volume-Specific Resistances (ρ_t) of Alloys at various Temperatures (pt).*

Alloy.	In boiling water.	Ordinary temp.	In melting ice.	In CO_2 and ether.	In liquid ethylene.	In liquid oxygen boiling at 760mm.	In liquid oxygen boiling in vacuum.
Platinum silver.	ρ = 32296	31726	31573	30964	30760	30173	...
P = 33 p.c. Ag = 66 p.c.	pt = 93·25	16·1	1·85	- 81·9	- 106·1	- 197·1	...
Platinum-Iridium.	ρ = 33271	31296	30933	28836	28347	26031	...
Pt = 80 p.c. Ir = 20 p.c.	pt = 93·3	16·1	1·8	- 81·9	- 106·1	- 197·1	...
Platinum-rhodium.	ρ = 23943	21635	21188	18648	18065	15134	...
Pt = 90 p.c. Rd = 10 p.c.	pt = 92·25	16·15	1·75	- 81·9	- 106·1	- 197·1	...
Gold-silver.	ρ = 6997	6417	6293	5666	5510	4817	...
Au = 90 p.c. Ag = 10 p.c.	pt = 91·65	16·4	0·9	- 81·9	- 106·1	- 197·1	...
Aluminium-silver.	ρ = 5686	4824	4654	3723	3477	2484	...
Al = 94 p.c. Ag = 6 p.c.	pt = 92·5	16·25	0·9	- 81·9	- 106·1	- 197·1	...
Aluminium-copper.	ρ = 3972	3087	2911	1960	1715	719	...
Al = 94 p.c. Cu = 6 p.c.	pt = 92·4	16·35	0·95	- 81·9	- 106·1	- 197·1	...
Copper-aluminium.	ρ = 9575	8990	8860	8210	8044	7328	...
Cu = 97 p.c. Al = 3 p.c.	pt = 92·25	16·35	0·85	- 81·9	- 106·1	- 197·1	...
Hadfield's manganese-steel.	ρ = 75294	68520	67222	61236	60042	55414	...
Mn = 12 p.c.	pt = 89·9	16·15	1·0	- 81·9	- 106·1	- 197·1	...
Hadfield's nickel-steel.	ρ = 35185	30402	29515	24897	23750	19468	...
Ni = 4·35 p.c.	pt = 91·15	16·15	0·95	- 81·9	- 106·1	- 197·1	...
Manganin.	ρ = 47528	47640	47636	47387	47225	45825	45270
Cu = 84 p.c. Mn = 12 p.c. Ni = 4 p.c.	pt = 91·60	16·25	0·9	- 81·9	- 106·1	- 197·1	- 217

Table II.—*Volume-Specific Resistances (ρ_t) of Alloys at various Temperatures (pt).*

Alloy.	In boiling water.	Ordinary temp.	In melting ice.	In CO_2 and ether.	In liquid ethylene.	In liquid oxygen boiling at 760mm.
German-silver	ρ = 30731	30112	29987	29297	29132	28317
	pt = 92·25	16·2	0·9	- 81·9	- 106·1	- 197·1
Platinoid	ρ = 42884	41938	41745	40683	40413	39189
	pt = 92·85	16·25	0·9	- 81·9	- 106·1	- 197·1
Titanium-Aluminium	ρ = 4936	4076	3898	2943	2705	1658
	pt = 90·85	16·4	0·85	- 81·9	- 106·1	- 197·1
Silverine. Cu = 77 p.c. Ni = 17 p.c. Fe = 2 p.c. Zn = 2 p.c. Co = 2 p.c.	ρ = 2614	2166	2071	1582	1452	909
	pt = 90·5	16·25	0·95	- 81·9	- 106·1	- 197·1
Copper-nickel-aluminium. Cu = 87 p.c. Ni = 6·5 p.c. Al 6·5 p.c.	ρ = 15785	15066	14921	14132	13939	13048
	pt = 91·45	16·35	0·9	- 81·9	- 106·1	- 197·1

appropriate length of the wire being cut off and measured against a standard-metre scale, it was drawn through the field of the microscope, the smallest gauge, F or G, being placed in the same focal plane and parallel with the wire. The gauge was placed with the flat side of the handle parallel with the screen and the centre of the steel gauge in the centre of the objective field. We had then on the screen the images or shadows of two objects, one a wire of steel of known diameter, and the other a wire of unknown diameter; the diametral planes of each wire being in the same focal plane of the lens. The diameters of the images of the steel gauge and the wire were then carefully measured with dividers and expressed in terms of some arbitrary unit. The ratio of these apparent image-diameters was taken as the ratio of the real diameters of the wire and the gauge. The measurement of the diameter of the wire was taken about every five centimetres in the case of very uniformly drawn wires, and more frequently in other cases. Generally about 20, and sometimes 60 diametral measurements were taken in the metre length of the wire to be measured, and as the wire was turned round its long axis in passing through the field of the microscope the diametral measurements were taken in numerous directions. The mean of all these measurements gave a close approximation to the mean diameter of the wire. As an instance of the close agreement of the results by this method, and those obtained by the density method, we may give the following comparison of the determination made of the mean diameter of a certain high conductivity copper wire about 0·01in. in diameter. Mr. J. W. Swan sent us this wire, and determined its mean diameter by a very careful measurement of its length and mean density. Our measurement of the mean diameter of this wire was 0·02609cm., and his was 0·02608cm., agreeing thus within 1 part in 2,600. By the use of a suitable objective this method was applicable to the smallest wires used as well as to the largest. Each wire having had its mean diameter and length thus ascertained, the mean cross-sectional area was calculated, and a reduction-factor obtained by which the reduced true resistance of the wire in ohms was multiplied to deduce therefrom the volume-specific resistance as above defined.

Furnished with these wires, the next step was to prepare suitable resistance coils, by which the resistance of the wires could be taken in a bath of liquid gas. In our former experiments, the wires of which the resistance was to be determined were wound on a rectangle of mica, having serrations or teeth cut upon the edge, and the ends of the wire were then soldered to stout copper connections. For many reasons this proved to be an undesirable method. Many wires, such as aluminium, were easily broken by the sharp bend in the wire, and other soft wires, such as lead, were deformed at the same point of bending. In preparing coils for the purpose we had in view it was necessary to keep them small, so that they might be easily contained in a moderate-sized vacuum-jacketted test tube in which the liquid was held. For obvious reasons also, any large amount of non-conducting material round the wire was objectionable. After some trials the following method of constructing the resistance coils to be used was adopted, and answered very well. Stout high-conductivity copper wire of 4mm. diameter was cut into lengths, and pairs of these wires bent up and bound together at the middle, but insulated from each other with india-rubber tape. The ends of the wires were well tinned, and the bottom ends nicked. A very thin sheet of vulcanised fibre was then bound round the bottom part of the copper rods, and sewn to them by silk thread. This formed a thin cylinder on which the wire to be tested was carried. A stout silk thread was then wound, spiral fashion, round the cylinder. The wire to be tested, generally one, two, or three metres in length, was then carefully wound on the fibre cylinder, in between the silk thread, the several turns of which kept the turns of wire from becoming short-circuited. The dimensions of the cylinder of vulcanised fibre varied according to the length of wire used, but was from two to three centimetres in diameter and four to five centimetres in length. A large number of such bobbins having been prepared, the next step was to anneal the wires on these coils. The so prepared resistance coils were immersed in melted paraffin wax, and kept at a temperature of 200°C. for some time. These being slowly cooled, they were annealed, and at the same time the insulating portions of the coils well saturated with paraffin.

The resistance measurements were carried out by means of a Wheatstone bridge by Messrs. Elliott Bros. The coils of this bridge were of platinum-silver, and adjusted to read in standard ohms. The coefficient of variation of resistance of the coils of the bridge with temperature was determined, and found

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to be 0·031 per cent. per degree Centigrade. The temperature of the bridge-coil box was always taken at the time of making each set of measurements, and the proper correction applied. Another correction of importance was that for resistance of the connecting leads and the copper terminals of each coil. A loop of copper wire was prepared of the same metal, and of the same total length, as the standard size employed as terminals of each resistance coil. This blank was always measured before and after each set of experiments on the coils, and so arranged that it was under the same temperature conditions as the terminals of the coils. This, together with the resistance of the short thick bridge leads, is always called "resistance of connections" in the Tables, and is a correction invariably applied in each case. The galvanometer employed with the bridge was a Pitkin-Holden galvanometer of the suspended coil type, having a resistance of about 10 ohms, and nearly perfectly dead-beat. One cell of a Helsen dry battery was used, and the usual battery and galvanometer keys inserted in their respective circuits. The temperatures above zero Centigrade were obtained by immersing the coils in a beaker of melted paraffin oil standing in a large zinc bath full of water. This water was heated to varying temperatures up to about 98° C. The paraffin was kept well stirred, either by a mechanical stirrer, or, better, by passing slowly bubbles of air through it from an elastic bag full of air. The temperature of the paraffin oil was taken by a mercury-in-glass thermometer, the scale readings of which were corrected for us by Mr. Casella by comparison with those of a standard mercury thermometer which had been checked at Kew. Temperatures close to zero Centigrade were chiefly obtained during the long frost in January, 1893, by placing the coils in paraffin oil in beakers which were placed in the zinc bath filled with broken ice. Coils waiting to take their turn to be measured were kept standing in other beakers of paraffin oil also placed in the same large zinc bath. Those who have conducted similar experiments know well that the great difficulty in such resistance measurements is to make sure that the coils have reached the temperature of the surrounding fluid, and to avoid changing their temperature by the current employed to measure them. For this reason very weak currents have to be used with the bridge. The temperatures below zero Centigrade were obtained by the use of a bath of carbonic acid snow, and ether, or paraffin oil, which gave temperatures according to desire from 0° C. down to about −78°C., and a series of measurements was thus made at about −40° and 78°. By the employment of liquid ethylene a temperature of −100°C. could be reached. Liquid oxygen was then employed as a refrigerating agent to lower the temperature of the resistance-coils to about −182°C. The liquid gas was contained in vacuum-jacketed flasks or test-tubes in which the resistance-coil was placed. Temperatures lower than the above limits were obtained by closing the mouth of the vacuum-jacketed test-tube with a tightly fitting india-rubber cork and producing a partial vacuum above the liquid oxygen. In these experiments the resistance coils were therefore immersed in liquid ozygen boiling under a very reduced pressure, as low as 14mm. of mercury. At all times great care is necessary to preserve the coil entirely immersed in the liquid gas. If the coil is only partially immersed thermoelectric effects are set up, in some cases of such a magnitude as to entirely vitiate the measurements of resistance. Hence the necessity for an abundant supply of the liquid gas. In some of the sets of experiments several litres of liquid oxygen were used up. In the above set of measurements about fifty coils in all were wound, and the measurements of each coil often taken several times at the same temperature. In those instances in which the temperature of the bath was below zero Centigrade the resistance of one of the standard platinum wires was measured in the same bath before and after each measurement of the resistance of the wire. The platinum-thermometer wire was thus placed under identical conditions with the wire under examination. In all the following Tables the temperatures in the columns headed pt are platinum temperatures taken with the standard platinum wire.

At this stage the authors give detailed accounts of their tests of samples of platinum, gold, palladium, silver, copper, aluminum, iron, nickel, tin, magnesium, zinc, cadmium, lead, and thallium.

The resistance curves of some of the above metals are delineated on the accompanying chart to a suitable scale. An examination of these lines will show that some of them are concave upwards and some concave downwards; those with the most marked curvature being the magnetic metals nickel and iron. The lines cross one another at low temperatures, and hence the order of conductivity of the metals at very low temperatures is different to their order at ordinary temperatures. At the lowest temperature reached the best metallic conductor is pure copper. It may be remarked that generally the best conductors amongst the pure metals are those that are most sonorous: silver, aluminium, gold, and copper would make good bells, whilst lead, thallium, tin, and palladium, which are the worst conductors, would be unsuitable for this purpose. The metals platinum, palladium, have resistance curves which have a marked concavity downwards when plotted in terms of Centigrade temperatures; whilst nickel and iron have a considerable curvature in the opposite direction. An examination of this chart will show that the conclusion reached in our former Paper is confirmed by these more careful experiments, viz., that the electrical specific resistance of all *pure* metals will probably vanish at the absolute zero of temperature.

An examination has also been made of a large number of alloys of known composition, and as the details are too numerous to tabulate in full, we append two Tables (I. and II.) which will show the volume-specific resistance in C.G.S. units of these various alloys at different temperatures stated in terms of platinum temperatures. At the same time the composition of the alloy is given. Also we add a Table III., in which the volume-specific resistance of each alloy is given at 0° C., and the temperature-coefficient at 15° C. The resistance-curves of these alloys are shown in the chart. Concerning these curves we may draw attention to the fact that the curve of Hadfield's manganese steel has a remarkably sudden change of curvature at about −40° C. It will be important to investigate the magnetic qualities of manganese steel at a temperature of from −30° C. to −80°, and see, if possible, what other physical changes take place at the time when the temperature-coefficient undergoes a rapid change. It will also be seen that the alloy manganin has a curve which has a maximum at 16° C. Hence manganin has a zero temperature-coefficient at 16° C., but a positive coefficient below that temperature, and a negative one above. It is very interesting to note the effects of the various constituent elements in the alloys. An admixture of 6 per cent. of silver with aluminium has a much greater effect in changing the specific resistance than 6 per cent. of copper, whilst 3 per cent. of aluminium has a greater effect still in changing the character of copper. We have collected together into Table IV. the volume-specific resistances of the pure metals, and also their mean temperature coefficients between 0°C. and 100°C.

Table III.—*Volume Specific Resistances* (ρ_0) *in C.G.S units of Alloys at 0°C., and Temperature-Coefficients* (α) *at 15°C.*

—	ρ_0	α_{15}
Platinum-Silver	31582	0·000243
Platinum-Iridium	30896	0·000822
Platinum-Rhodium	21142	0·00143
Gold-Silver	6280	0·00124
Manganese-Steel	67148	0·00127
Nickel-Steel	29152	0·00201
German-Silver	29982	0·000273
Platinoid	41731	0·00031
Manganin	46678	0·0000
Silverine	2064	0·00285
Aluminium-Silver	4641	0·00238
Aluminium-Copper	2904	0·00381
Copper Aluminium	8847	0·000897
Copper-Nickel-Aluminium	14912	0·000645
Titanium-Aluminium	3887	0·00290

Table IV.—*Volume-Specific Resistances in C.G.S. Units of Pure Metals at 0°C., and Mean Temperature-Coefficients between 0° and 100°C. The metals in all cases soft and annealed.*

Metal.	ρ_0.	α_{0-100}
	C.G.S. units.	
Platinum	10917	0·003669
Gold	2197	0·00377
Palladium	10219	0·00354
Silver	1468	0·00400
Copper	1561	0·00428
Aluminium	2665	0·00435
Iron	9065	0·00625
Nickel	12325	0·00622
Tin	13048	0·00440
Magnesium	4355	0·00381
Zinc	5751	0·00406
Cadmium	10023	0·00419
Lead	20380	0·00411
Thallium	17633	0·00393

In conclusion we desire to express our indebtedness to Messrs. J. and D. Morris for the valuable assistance they have given us in the conduct of this research, and in the reduction and graphic description of the numerous observations. We hope, in a future communication, to be able to state the results of similar observations at still lower temperatures.

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THE PRACTICAL MEASUREMENT OF ALTERNATING ELECTRIC CURRENTS.

BY PROF. J. A. FLEMING, F.R.S.*

(Concluded from page 507.)

IV.—*Measurement of Alternating Current Energy.*

In this fourth and last lecture I propose to discuss the practical measurement of alternating current energy and alternating current quantity. In so doing, we shall begin by dealing with the easier problem in the measurement of such quantities, viz., when the circuits to which the power or current is being supplied are non-inductive, and then proceed to consider the more difficult case, in which the circuits are inductive circuits, such as the primary circuits proceeding out from alternating current stations.

Instruments for the measurement of alternating-current energy or quantity are called simply meters, and they are classified into ampere-hour meters and watt-hour meters. A complete classification of all the different forms of meter already invented would be a rather difficult thing to make on a perfectly correct basis. I shall give you presently an approximate classification. In the first case, we will consider the simplest forms of meter, which may be called graphic ammetersand wattmeters. Of these two, the Holden ammeter and Mengarini wattmeter are good examples In these instruments an arm carrying a pen is displaced over a paper-covered drum, which is revolved uniformly in 24 hours by a clock. The motion by which the pen is displaced is regulated by a part of the instrument which is simply an ammeter or a wattmeter, and the displacement of the pen is proportional to the current or the power passing through this measuring part. When, therefore, the diagram is cut off and unrolled, we find on the paper a curve which represents, by its ordinates, either the power or the current at any instant; and, if the whole area of the curve is integrated, then such area represents the whole energy or quantity which has passed through the meter in 24 hours. These instruments have the advantage, therefore, that we practically record two quantities at once; and they serve two purposes, of indicating the instantaneous current or power, and the total current quantity or energy; but they have the disadvantage that they are not self-integrating.

Next in order of simplicity are the self-integrating ammeter and self-integrating wattmeter. One of the simplest of these self-integrating ammeters, but which is, however, available only for the measurement of alternating current quantity, is the well-known Shallenberger meter. The principle of the Shallenberger meter is not a difficult one to understand. It consists of a small transformer, one coil of which we may call the primary, and which is in series with the circuit in which the current to be measured is flowing. The core of this transformer consists of a little soft iron disc, which is capable of revolving on an axis. This axis is geared at the top with a counting mechanism, which records the number of revolutions of the disc, and at the bottom there is a vane or fan of thin aluminium, which serves to retard the rotation of the disc. The secondary circuit of this transformer consists of a small coil of copper, which is closed upon itself, and which is placed with its axis inclined at 45deg. to the axis of the primary coil. When the primary current flows through the primary coil it does two things—it magnetises the core, and it induces a secondary current in the closed secondary circuit. It is not difficult to show that the phase of this secondary current must be about 90deg. behind the phase of the primary current, and also that the magnetism of the iron core, which is in a direction at right angles of the plane of the primary coils, also lags in phase behind the primary current by about 90deg. The magnetism of the core and the induced secondary current are, therefore, in step, and are in such directions that the axis of the disc is always being pulled round by the induced field of the secondary coil. If, then, there were no friction of any kind, the iron disc would be continually accelerated in speed, but since the air friction varies approximately as the square of the velocity, and since the mean driving force is proportional to the mean square of the current strength, it follows that the total number of revolutions which the disc makes in any given time is proportional to the total mean quantity or ampere hours which have passed the primary circuit. The meters can, therefore, be calibrated by a constant in such a way that they read directly ampere hours, and if the pressure between the mains is kept constant, they may be graduated to read in Board of Trade units.

These meters are very simple to construct and very fairly accurate in performance, and they have, therefore, come into extensive use. The velocity of the disc being at any time proportional to the mean current passing through the meter, we can, if the current is kept tolerably constant, employ the instrument as an ammeter. By moving the position of the secondary coil a little adjustment can be made in the meter for change of frequency, and the meter can be calibrated for the particular frequency for which it is intended to be used. The next meter in order of simplicity, and very similar in principle to the Shallenberger, is the Wright-Ferranti meter. It is also a self-integrating ammeter; it measures at any instant the mean square current, and gives us the mean quantity which is passed through the meter. The indicating part of the meter consists of a wheel with a light iron rim. This wheel is nearly embraced by two curved horns of laminated iron. These horns spring from the corners of a rectangle of laminated iron. This laminated iron rectangle is wound over on all four sides with two coils of wire. Through one of these coils the current to be measured passes, and the other coil is a shunt coil, the function of which I shall describe presently. The arrangements of the coil are such that any moment the ends of the curved horns are opposite magnetic poles. On these curved horns are placed copper rings. When the alternating current passes through the series coil it creates alternating magnetism in these curved horns, but owing to the eddy currents of the set up in these embracing rings, the magnetic lines of force are thrust outwards, making a lateral leakage field, which travels up the horn. This leakage field induces eddy currents in the iron disc, and the disc is thereby repelled in virtue of the electromagnetic repulsion set up between the horn and the wheel. When an alternating current is passed through the meter it tends to drive the wheel round with a speed which is proportional to the mean-square strength of the current, and, therefore, it follows that the number of revolutions made by the wheel at a given time is proportional to the mean quantity in ammeter hours which has passed through the meter at that time. Both the Shallenberger meter and the Wright-Ferranti meter require to be calibrated for the particular frequency for which they are to be used, and they only give Board of Trade units provided that the pressure is kept constant between the supply mains. The meter really reads quantity directly, and power only on the assumption of the constancy of pressure. I mentioned that there were two circuits on the electromagnet, and that one of these was the shunt circuit. The function of this shunt circuit is to supply the driving force which overcomes the friction of the counting train. If this shunt circuit were not present, there would be a frictional resistance to be overcome before the meter would start at all.

Another meter, of a tolerably simple character, also intended for measuring ampere hours, is the windmill meter, invented by Prof. Forbes some years ago. In that meter there is a coil of wire, which was heated by the current passing through it. This heated coil generates an upward current of air, and this upward current of air is made to turn round a very delicately constructed windmill with mica vanes. The counting train attached to the windmill records the number of turns in a given time. Although this may seem to have been a somewhat unpromising principle to apply, yet the meter in itself gave excellent results.

We turn next to the consideration of the second great class of meters, namely, the watt-hour meters, which are self-integrating. These self-integrating watt-hour meters may also be divided into two classes, continuously and intermittently integrating. Taking the last class first, this is well represented by the Frager meter. In this meter there are two distinct parts; first, the wattmeter part, which measures at any instant the power, and the integrating part, which integrates at intervals the power and the time. The wattmeter part consists of a wattmeter having a thick coil, which is a series coil, and a movable coil, which is suspended by a steel wire which is shunted across the circuit. The terminals of the shunt coil are connected to the two sides of the mains, and the current to be measured is passed through the series coil. Attached to the movable shunt coil is a long arm, and the displacement of this arm varies with the power passing through the instrument. Adjacent to the wattmeter and fixed on the same base is an electrical clock, which drives round a curved plate of metal, which is technically termed "the snail." On the end of the long projecting arm attached to the wattmeter is a small steel point. As the snail is turned round it passes underneath this arm, and if this arm is displaced, the length of the path of the pointer, when travelling over the snail, is proportional to the power passing through the wattmeter. The snail plate is so suspended that when the pointer passes over it it presses it down, and makes an engagement between the snail and the counting mechanism. At each revolution of the snail the counting mechanism is turned round by a number of revolutions which are proportional to the mean power or watts passing, and hence the total number of revolutions in any given time is proportional to the watt-hours which have passed through the meter. The snail revolves round in a period which is about three minutes, and hence the record is, as it were, made of the power passing through the wattmeter only at intervals of three minutes. If the current which is to be measured does not vary very rapidly, such an intermittent recording meter may be made to give very accurate results, but there are many cases, such as in theatres, where the amount of current passing through the meter is very irregular and

* Abstract of Cantor Lecture delivered before the Society of Arts, February, 1893.

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rapidly varied. Under these conditions the wattmeter needle is thrown about in such a manner that the actual power recorded on the dials at every revolution is not always the true mean power passing in the interval between two revolutions, and the readings of the meter may, therefore, become very erroneous. Practice has confirmed these inferences, and although the Frager meter is under some conditions of use a very accurate meter, there are other conditions under which its readings are not to be depended on.

Coming next to the continuously recording watt-hour meters, we reach that class of meter which may be said to be the best adapted for general wants, and one of the most efficient of these continuously recording watt-hour meters is the one invented by Prof. Elihu Thomson. The Thomson recording wattmeter is a wattmeter in which one coil, called a series coil, carries the current to be measured. This series coil really forms the field-magnet of a very small electromotor. The armature of this motor is a beautiful one, having a small commutator and brushes of the usual kind, and this armature circuit, together with the external added resistance, constitutes the shunt circuit of the wattmeter. When the meter is attached to a circuit, the main current of which passes through the series coils, and the shunt coil being attached to the two mains, the armature begins to revolve. The shaft which carries the armature carries also a copper disc, which is embraced by three horse-shoe magnets. When the disc revolves, eddy currents are set up in the disc which retard its motion. The number of revolutions of the disc in a given time is recorded by the counting mechanism attached to the shaft. Then since the force driving the armature round is at any instant proportional to the power passing through the instrument, and since the retarding force is proportional to the velocity, it follows that the number of revolutions in a given time represents the watt hours that have passed through the meter. In order to overcome the constant friction of the train, there is a compound winding on the field-magnet, consisting of a few turns of the shunt coil, which is arranged in such a direction that the driving force due to the fixed and movable shunt-winding, tends to overcome the permanent friction of the armature shaft. By properly treating the permanent magnets it is found that they retain a constant magnetism for long periods of time. The meter is so arranged that when working on a 100-volt circuit the shunt coil has a resistance of 1,000 ohms altogether, and takes, therefore, 0·1 of an ampere. The loss in the meter, therefore, is only 10 watts, which is the power taken up in driving the meter. By properly arranging the shunt coil it is possible to make the constant of this meter perfectly constant for a very large range of its action, and one great advantage which this meter has is that it can be employed with both alternating and continuous currents. When properly adjusted this watt-hour meter is capable of very great accuracy in the measurement of alternating-current energy.

Reviewing, then, the whole of these meters, we may say that a rough classification of meters for the measurement of alternating currents may be made as follows :—

1. Graphic recording ammeters.
2. Graphic recording wattmeters.
3. Continuously recording ampere-hour meters.
4. Intermittent recording wattmeters.
5. Continuously recording wattmeters.

We may ask ouselves at this stage what ought to be the characteristics and requirements in a good commercial meter for the measurement of electric energy supply to houses for lighting and other purposes. Most persons without experience would probably say that the first requirement in a meter is accuracy ; but as a practical matter accuracy is not of so much importance as that the meter should never go far wrong. A type of meter which is capable of measuring, under some conditions, to 0·1 of accuracy, and at other times is liable to make errors of 150 per cent. in actual practice, is not nearly so useful as a meter which will not read closer than 1 per cent., and yet which, in actual practice, never proves to go more than 3 per cent. wrong. The next condition which a meter must comply with is that of the consumption of small power. Since the meter is connected to the circuit continually, if it absorbs power, the sum total of all these consumptions may amount to a serious item. We have pointed out, in speaking of voltmeters, that a continuous power absorption, say, of 20 watts, during the whole year amounts to a yearly consumption of 160 units of electric energy, and that, therefore, small power consumption is certainly an important item in appraising a meter. The third great requisite is that the meter ought not to require elaborate care and delicacy in fixing, and that it ought to be hardy enough to be easy of carriage. House meters have to be fixed in places which are sometimes subject to vibration and dampness, &c., and a meter for house purposes ought, therefore, to be hardy enough to stand these conditions. The fourth condition is that the meter must be so constructed in principle as not to be capable of being easily tampered with, or its indications made to vary, even when enclosed in a lock-up case. To the above requirements ought, of course, to be added the broad and general conditions of simplicity of structure and cheapness in price, as far as consistent with good workmanship.

I now turn to the important subject of the measurement of alternating current power when supplied to inductive circuits ; in other words, we have to study alternating current primary meters. In the distribution of alternating currents for commercial purposes, not only is it necessary to be able to measure the power or energy supplied to the consumer on the lamp circuits, but it is also necessary to be able to measure the power and energy sent out from the alternating-current station which is supplying, generally, transformer circuits. Hence, we have to consider the special difficulties of making such measurements on circuits which have a considerable self-induction, or in which the power-factor of the circuits is below unity. During the past year or two I have paid particular attention to this subject, in a long series of researches on the efficiency of transformers, and have thereby been led to study most of the various methods which have, from time to time, been proposed for measuring alternating-current energy. I do not propose to occupy the time in discussing any of the methods which, however well they look on paper, are yet, for some reason or other, inapplicable in practice, but to describe the methods which have proved themselves, in my experience, satisfactory and practicable in making these measurements. I have found that the two instruments for this purpose which are capable of being employed with very satisfactory rssults for the measurement of alternating-current energy on inductive circuits are the Thomson recording wattmeter and the Mengarini wattmeter already described.

Generally speaking, these measurements have to be made on high-tension circuits. Take, for instance, the very common case of an alternating-current station, supplying alternating current at a pressure of 2,000 volts on transformer circuits. One method of employing either of the above wattmeters as energy meters would be to place a non-inductive resistance of sufficient magnitude in series with a shunt coil, and to put the series coil in the series with one of the primary mains. In such an arrangement there would be certain disadvantages. In the first place, the Thomson recording wattmeter takes a current of about one-tenth of an ampere through the shunt, and hence we should have to add to the shunt coil, the resistance of which is about 1,000 ohms, another 19,000 ohms of non-inductive resistance, and then, when this was done, the power wasted in the whole of these shunt circuits would be 200 watts. If these shunt circuits were kept connected to the mains throughout the whole year, the waste of energy in these shunt circuits would be something like 1,600 Board of Trade units, and if we reckon the manufacturing cost of these at only 2d. a unit, it would cost something like £12 per annum merely to supply the shunt circuit with current. But this difficulty can be got over, and also the difficulty of constructing a large non-inductive resistance of 20,000 ohms, sufficiently well divided up not to be in any danger of breaking down with 2,000 volts pressure, by the adoption of a transformer to excite the shunt circuits in the way described in my last lecture. A small transformer is employed, transforming down from 2,000 volts to 100 volts, and as this transformer is only to supply one-tenth of an ampere on its secondary circuit, it can be made very small, not more than, say, a tenth of horse-power in capacity. It can, therefore, be made to waste not more than about 10 to 20 watts in itself. This transformer has its primary circuits connected across the primary mains, and its secondary circuit is connected across the terminals of the shunt circuit of the Thomson wattmeter, and so joined up that the current in the shunt circuit of the wattmeter is in the same direction and has the same magnitude as if the wattmeter were joined up simply on a 100-volt circuit in the ordinary way. The wattmeter in itself only wastes about 10 watts in its shunt circuit, and, therefore, the whole arrangement of the transformer and wattmeter can be made to waste not more than, say, 25 to 30 watts, instead of 200, and reduce the cost of up-keep to something like 200 units a year instead of 1,600 The primary current going out of the station is then taken through the series coil of the Thomson wattmeter, and in order to keep all the parts of the wattmeter at the same potential one terminal of the secondary circuit and the little transformer is also joined up to the primary main on the side nearest to it. It is usual to mount the transformer and wattmeter on one board, and then to insulate the whole of this board well. The first step is to calibrate the wattmeter. This can be done most easily on a 100-volt circuit by passing through the meter known powers, and observing the reading of the dials. The constant of the meter then has to be multiplied by the transformation ratio of the small transformer, in order to obtain what may be called the high tension constant of the meter. When this is done the meter can be set up in the station in such a way that the whole current going out of the station passes through the meter, and the engineer can, by taking observations from day to-day, record the whole number of units which have been sent out from the generating station on the primary circuits in any interval of time. In exactly the same manner I have found it possible to employ a Mengarini wattmeter coupled with a transformer and placed on the primary circuit. This

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has the advantage that it not only enables us to record the whole of the energy going out of the station in a given time, but to know at any instant the primary watts.

Before placing confidence in either of these two methods, I made a very careful series of observations on an inductive alternating current primary circuit, in which I employed the Thomson self-integrating wattmeter, as above described, to measure the whole number of units sent out along that primary circuit in four hours, and at the same time observations were made on the same circuit by means of a wattmeter to obtain the power sent out at intervals of minutes. When these observations were compared and reduced, it was found that the power sent out in four hours, as determined by the observations, was 66·924 units in the wattmeter, and the energy given by the self-integrating Thomson wattmeter in the same time was 66·946. It thus became evident that the Thomson recording wattmeter was capable of giving very accurate results as a primary wattmeter, and that there is no reason whatever why the record of the primary energy sent out should not be made in alternating-current stations with the same accuracy as in the case of continuous-current stations.

To complete arrangements it would be desirable, in the case of an alternating-current station, in order to enable the engineer to know exactly what the result of his working is, to act as follows :— On the primary should be placed, in the first place, an ammeter, capable of measuring alternating currents and giving the mean-square value. In the second place, an electrostatic high-tension voltmeter should be connected across the mains in order to give the high-tension volts. In front of this instrument should be placed a Mengarini wattmeter and a Thomson self-recording wattmeter, the whole primary current from the station going through the series coils of these instruments. The shunt circuits of these instruments should be excited by a small transformer, transforming *down from* a working pressure of 100 to 50 volts. These instruments would then enable the engineer, by daily readings, to record, first, the energy sent out of the primary circuits in Board of Trade units in any time ; secondly, the power being sent out at any instant measured in watts ; thirdly, the primary current being sent out at any instant, and the primary pressure, and, therefore, from the product of these two, the apparent power being sent out at any instant ; and fourthly, from the readings of the real and apparent power, the power factor of the station could be ascertained at any instant. By comparing these readings with the sum total of the house meters taken at any intervals, the engineer would be enabled to know the efficiency of distribution of his alternating-current station, and to reckon out, not only the cost of the unit sold. but the cost of the unit generated, and to watch and know the effect of any improvements that are made in the transformers on the system.

It is only by adopting such methods of measurement that engineers in charge of alternating-current stations will be able to remove the reproach which is sometimes hurled at them, that they have no means of measuring the energy or power they are supplying, or of knowing how much of what they make is sold.

MR. R. T. GLAZEBROOK'S PRESIDENTIAL ADDRESS TO SECTION A.

[ABSTRACT.]

Before dealing with the subject which I hope to bring to your notice this morning, I wish to express my deep regret for the circumstances which have prevented Prof. Clifton, who had accepted the nomination of the Council, from being your President this year. It was specially fitting that he who has done so much for this college, and particularly for this laboratory in which we meet, should take the chair at Nottingham. The occasions on which we see him are all too seldom ; and we who come frequently to these meetings were looking forward to help and encouragement in our work, derived from his wide experience. You would desire, I feel sure, that I should convey to him the expressions of your sympathy. For myself I must ask that you will pass a lenient judgment on my efforts to fill his place. Let me commence, then, with a brief retrospect of the past year and the events which concern our Section.

The conference on electrical standards held at our meeting last year has had important results. The resolutions adopted at Edinburgh were communicated to the Standards Committee of the Board of Trade. A supplementary report accepting these resolutions was agreed to by that Committee (November 29, 1892), and presented to the President of the Board of Trade. The definitions contained in this report will be made the basis of legislation throughout the world. They have been accepted by France, Germany, Austria, and Italy. There is good reason to believe that the congress at Chicago now being held will ratify them, and then we may claim that your Committee, co-operating with the leaders of physical science in other lands, has secured international agreement on these fundamental points. Among the physical Papers of the year I would mention a few as specially calling for notice. Mr. E. H. Griffiths's redetermination of the value of the mechanical equivalent of heat has just been published,* and is a monumental work. With untiring energy and great ability he struggled for five years against the difficulties of his task, and has produced results which, with the exception of one group of experiments, do not differ by more than 1 part in 10,000 ; while the results of that one excepted group differ from the mean only by 1 part in 4,000. The number of ergs of work required to raise 1 gramme of water 1°C. at 15°C. is $4{\cdot}194 \times 10^7$. Expressed in foot-pounds and Fahrenheit degrees, the value of J is 778·99. The value obtained by Joule from his experiments on the friction of water, when corrected in 1880 by Rowland so as to reduce his readings to the air thermometer, is 778·5 at 12°·7 C. The result at this temperature of Rowland's own valuable research is 780·1. Another satisfactory outcome of Mr. Griffiths's work is the very exact accordance between the scale of temperature as determined by the comparison of his platinum thermometer with the air thermometer, which was made by Callendar and himself in 1890, and that of the nitrogen thermometer of the Bureau International at Sèvres. Another great work now happily complete is Rowland's "Table of Standard Wavelengths."† Nearly a thousand lines have been measured with the skill and accuracy for which Rowland has made himself famous ; and in this table we see the results achieved by the genius which designed the concave grating and the mechanical ingenuity which contrived the almost perfect screw. Those of us who have seen Mr. Higgs's wonderful photographs of the solar spectrum taken with a Rowland grating will rejoice to know that his map also is now finished. Lord Rayleigh's Paper on "The Intensity of Light Reflected from Water and Mercury at nearly Perpendicular Incidence,"‡ combined with the experiments on reflection from liquid surfaces in the neighbourhood of the polarising angle,§ establishes results of the utmost importance to optical theory. "There is thus," Lord Rayleigh concludes, "no experimental evidence against the rigorous application of Fresnel's formulæ"—for the reflection of polarised light—"to the ideal case of an abrupt transition between two uniform transparent media." Prof. Dewar has, during the year, continued his experiments on the liquefaction of oxygen and nitrogen on a large scale. To a physicist, perhaps, the most important results of the research are the discovery of the magnetic properties of liquid oxygen, and the proof of the fact that the resistance of certain pure metals vanishes at absolute zero.‖ The last discovery is borne out by Griffiths and Callendar's experiments with their platinum thermometers.¶ Mr. Williams's article on "The Relation of the Dimensions of Physical Quantities to Directions in Space"** has led to an interesting discussion. Some of his deductions will be noticed later. The title-page of the first edition of Maxwell's "Electricity and Magnetism" bears the date 1873. This year, (1893) we welcome a third edition, edited by Maxwell's distinguished successor, and enriched by a supplementary volume, in which Prof. J. J. Thomson describes some of the advances made by electrical science in the last twenty years. The subject matter of this volume might well serve as a text for a Presidential Address.

The choice of a subject on which to speak to-day has been no easy task. The field of physics and mathematics is a wide one. There is one matter, however, to which for a few minutes I should like to call your attention, inadequately though it be. Optical theories have, since the year 1876, when I first read Sir George Stokes's "Report on Double Refraction,"†† had a special interest for me, and I think the time has come when we may with advantage review our position with regard to them, and sum up our knowledge.‡‡ That light is propagated by an undulatory motion through a medium which we call the ether is now an established fact, although we know but little of the nature or constitution of the ether. The history of this undulatory theory is full of interest, and has, it appears to me, in its earlier stages been not quite clearly apprehended. Two theories have been proposed to account for optical phenomena. Descartes was the author of the one, the emission theory. Hooke, though his work was very incomplete, was the founder of the undulatory theory. In his "Micrographia,"

* *Phil. Trans.*, Vol. CLXXXIV. ; *The Electrician*. Vol. XXX., p. 500.

† *Phil. Mag.*, July, 1893.

‡ *Phil. Mag.*, October, 1892 ; *The Electrician*, Vol. XXIX., p. 601.

§ *Phil. Mag.*, January, 1892.

‖ *Phil. Mag.*, October, 1892.

¶ *Phil. Mag.*, December, 1892.

** *Phil. Mag.*, September, 1892 ; *The Electrician*, Vol. XXIX., p. 258.

†† *British Association Report*, 1862.

‡‡ This address was in the printer's hands when I saw Sir G. Stokes's Paper on "The Luminiferous Ether," *Nature*, July 27th. Had I known that so great a master of my subject had dealt with it so lately, my choice might have been different ; under the circumstances it was too late to change.

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1664, p. 56, he asserts that light is a quick and short vibratory motion, "propagated every way through an homogeneous medium by direct or straight lines extended every way like rays from the centre of a sphere. . . . Every pulse or vibration of the luminous body will generate a sphere which will continually increase and grow bigger, just after the same manner, though indefinitely swifter, as the waves or rings on the surface do swell into bigger and bigger circles about a point on it;" and he gives on this hypothesis an account of reflexion, refraction, dispersion, and the colours of thin plates. In the same work, p 58, he describes an experiment practically identical with Newton's famous prism experiment, published in 1672. Hooke used for a prism a glass vessel about 2ft. long, filled with water, and inclined so that the sun's rays might enter obliquely at the upper surface and traverse the water. "The top surface is covered by an opaeous body, all but a hole through which the sun's beams are suffered to pass into the water, and are thereby refracted" to the bottom of the glass, "against which part if a paper be expanded on the outside there will appear all the colours of the rainbow—that is, there will be generated the two principal colours, scarlet and blue, with all the intermediate ones which arise from the composition and diluting of these two." But Hooke could make no use of his own observation; he attempted to substantiate from it his own theory of colours, and wrote pure nonsense in the attempt; and though his writings contain the germ of the theory, and in the light of our present knowledge it seems possible that he understood it more thoroughly than his contemporaries believed, yet his reasoning is so utterly vague and unsatisfactory that there is little ground for surprise that he convinced but few of its truth.

And then came Newton. It is claimed for him, and that with justice, that he was the true founder of the emission theory. In Descartes' hands it was a vague hypothesis. Newton deduced from it by rigid reasoning the laws of reflection and refraction; he applied it with wondrous ingenuity to explain the colours of thin and of thick plates and the phenomena of diffraction, though in doing this he had to suppose a mechanism which he must have felt to be almost impossible; a mechanism which in time, as it was applied to explain other and more complex phenomena, became so elaborate that, in the words of Verdet, referring to a period one hundred years later, "all that is necessary to overturn this laborious scaffolding is to look at it and try to understand it."

But though Newton may with justice be called the founder of the emission theory, it is unjust to his memory to state that he accepted it as giving a full and satisfactory account of optics as they were known to him. When he first began his optical work he realised that facts and measurements were needed, and his object was to furnish the facts. He may have known of Hooke's theories. The copy of the "Micrographia" now at Trinity College was in the library while Newton was working with his prism in rooms in college, and may have been consulted by him. An early note-book of his contains quotations from it. Still there was nothing in the theories but hypotheses unsupported by facts, and these would have no charm for Newton. The hypotheses in the main are right. Light is due to wave motion in an all-pervading ether; the principle of interference, vaguely foreshadowed by Hooke ("Micrographia," p. 66), was one which a century later was to remove the one difficulty which Newton felt. For there was one fact which Hooke's theory could not then explain, and till that explanation was given the theory must be rejected; the test was crucial, the answer was decisive. Newton tells us repeatedly what the difficulty was. In reply to a criticism of Hooke's in 1672, he writes: "For to me the fundamental supposition itself seems impossible, namely, that the waves or vibrations of any fluid can, like the rays of light, be propagated in straight lines without continual and very extravagant spreading and bending into the quiescent medium where they are terminated by it. I mistake if there be not both experiment and demonstration to the contrary. . . . For it seems impossible that any of those motions or pressions can be propagated in straight lines without the like spreading every way into the shadowed medium." Nor was there anything in the controversy with Hooke, which took place about 1675, to shake this belief. Hooke had read his Paper describing his discovery of diffraction. He had announced it two years earlier, and there is no doubt in my mind that this was an original discovery, and not, as Newton seemed to imply soon after, taken from Grimaldi; but his Paper does not remove the difficulty. Accordingly, we find in the "Principia" Newton's attempted proof (lib. ii. prop. 42) that "motus omnis per fluidum propagatus divergit a recto tramite in spatia immota"—a demonstration which has convinced but few and leaves the question unsolved as before. Again, in 1690, Huygens published his great "Traité de la Lumière," written in 1678. Huygens had clearer views than Hooke on all he wrote; many of his demonstrations may be given now as completely satisfactory, but on the one crucial matter he was fatally weak. He, rather than Hooke, is the true founder of the undulatory theory, for he showed what it would do if it could but explain the rectilinear propagation. The reasoning of the latter part of Huygens' first chapter becomes forcible enough when viewed in the light of the principle of interference enunciated by Young, November 12, 1801, and developed, independently of Young, by Fresnel in his great memoir on "Diffraction" in 1815; but without this aid it was not possible for Huygen's arguments to convince Newton, and hence in the "Opticks" (Second edition, 1717) he wrote the celebrated Query 28: "Are not all hypotheses erroneous in which light is supposed to consist in pressure or motion propagated through a fluid medium? If it consisted in motion propagated either in an instant or in time it would bend into the shadow. For pressure or motion cannot be propagated in a fluid in right lines beyond an obstacle which stops part of the motion, but will bend and spread every way into the quiescent medium which lies outside the shadow." These were his last words on the subject. They prove that he could not accept the undulatory theory; they do not prove that he believed the emission theory to give the true explanation. Yet, in spite of this, I think that Newton had a clearer view of the undulatory theory than his contemporaries, and saw more fully than they did what that theory could achieve if but the one difficulty were removed. This was Young's belief, who writes:—* "A more extensive examination of Newton's various writings has shown me that he was in reality the first who suggested such a theory as I shall endeavour to maintain: that his own opinions varied less from this theory than is now almost universally believed; and that a variety of arguments have been advanced as if to meet him which may be found in a nearly similar form in his own works." I wish to call attention to this statement, and to bring into more prominent view the grounds on which it rests, to place Newton in his true position as one of the founders of the undulatory theory. The emission theory in Newton's hands was a dynamical theory; he traced the motion of material particles under certain forces, and found their path to coincide with that of a ray of light; and in the "Principia," prop. xcvi, Scholium, he calls attention to the similarity between these particles and light. The particles obey the laws of reflection and refraction; but to explain why some of the incident light was reflected and some refracted Newton had to invent his hypothesis of fits of easy reflection and transmission.

Such was Newton's theory. It accounts for some or all of the observed facts; but what causes the fits? Newton, in the "Opticks," states that he does not inquire; he suggests, for those who wish to deal in hypotheses, that the rays of light striking the bodies set up waves in the reflecting or refracting substance which move faster than the rays and overtake them. When a ray is in that part of a vibration which conspires with its motion it easily breaks through the refracting surface—it is in a fit of easy transmission; and, conversely, when the motion of the ray and the wave are opposed, it is in a fit of easy reflection. But he was not always so cautious. At an earlier date (1675) he sent to Oldenburg, for the Royal Society, an "Hypothesis explaining the Properties of Light;" and we find from the journal book that "these observations so well pleased the society that they ordered Mr. Oldenburg to desire Mr. Newton to permit them to be published." Newton agreed, but asked that publication should be deferred till he had completed the account of some other experiments which ought to precede those he had described. This he never did, and the hypothesis was first printed in Birch's "History of the Royal Society," Vol. III., pp. 247, 262, 272, &c.; it is also given in Brewster's "Life of Newton," Vol. I., App. 2, and in the *Phil. Mag.*, September, 1846, pp. 187-213. "Were I," he writes in this Paper, "to assume an hypothesis, it should be this, if propounded more generally, so as not to assume what light is, further than that it is something or other capable of exciting vibrations of the ether. First, it is to be assumed that there is an ethereal medium, much of the same constitution with air, but far rarer, subtiller, and more strongly elastic. . . . In the second place, it is to be supposed that the ether is a vibrating medium, like air, only the vibrations far more swift and minute; those of air made by a man's ordinary voice succeeding at more than half a foot or a foot distance, but those of ether at a less distance than the hundred-thousandth part of an inch. And as in air, the vibrations are some larger than others, but yet all equally swift . . . so I suppose the ethereal vibrations differ in bigness, but not in swiftness. . . . In the fourth place, therefore, I suppose that light is neither ether nor its vibrating motion, but something of a different kind propagated from lucid bodies. They that will may suppose it an aggregate of various peripatetic qualities. Others may suppose it multitudes of unimaginable small and swift corpuscles of various sizes springing from shining bodies at great distances one after the other, but yet without any sensible interval of time. . . . To avoid dispute, and make this hypothesis general, let every man here take his fancy; only, whatever light be, I would suppose it consists of successive rays differing from one another in contingent circumstances, as bigness, force, or vigour, like as the sands on the shore . . . and further, I would suppose it diverse from the vibrations of the ether. . . . Fifthly, it is to be supposed that light and ether mutu-

* *Phil. Trans.*, November 12, 1801.

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ally act upon one another." It is from this action that reflection and refraction come about; "æthereal vibrations are, therefore," he continues, "the best means by which such a subtile agent as light can shake the gross particles of solid bodies to heat them. And so, supposing that light, impinging on a refracting or reflecting ethereal superficies puts it into a vibrating motion, that physical superficies being by the perpetual appulse of rays always kept in a vibrating motion, and the ether therein continually expanded and compressed by turns, if a ray of light impinge on it when it is much compressed, I suppose it is then too dense and stiff to let the ray through, and so reflects it; but the rays that impinge on it at other times, when it is either expanded by the interval between two vibrations or not too much compressed and condensed, go through and are refracted. . . . And now to explain colours. I suppose that as bodies excite sounds of various tones, and, consequently, vibrations in the air of various bignesses, so when the rays of light by impinging on the stiff refracting superfices excite vibrations in the ether, these rays excite vibrations of various bignesses . . . the biggest with the strongest colours, reds and yellows; the least with the weakest, blues and violets; the middle with green; and a confusion of all with white." The last idea, the relation of colour to the bigness of wave-length, is put even more plainly in the "Opticks," query 13 (ed. 1704):—"Do not several sorts of rays make vibrations of various bignesses, which according to their bignesses excite sensations of various colours . . . and, particularly, do not the most refrangible rays excite the shortest vibrations for making a sensation of deep violet; the least refrangible, the largest for making a sensation of deep red?"

Thus Newton, while in the "Opticks" he avoided declaring himself as to the mechanism by which the fits of easy reflection and transmission were produced, has in his earlier writings developed a theory practically identical in many respects with modern views, though without saying that he accepted it. It was an hypothesis; one difficulty remained, it would not account for the rectilinear propagation, and it must be rejected till it did. Light is neither ether nor its vibrating motion; it is energy which, emitted from luminous bodies, is carried by wave motion in rays, and falling on a reflecting surface sets up fresh waves, by which it is in part transmitted and in part reflected. Light is not material, but Newton nowhere definitely asserts that it is. He "argues the corporeity of light, but without any absolute positiveness." In the "Principia," writing of his particles, his words are:—"The reflections and refractions of light are not very unlike these attractions. Therefore, because of the analogy which exists between the propagation of rays of light and the motion of bodies, it seemed right to add the following propositions for optical purposes, not at all with any view of discussing the nature of rays (whether they are corporeal or not, but only to determine paths of particles which closely resemble the paths of rays." No doubt Newton's immediate successors interpreted his words as meaning that he believed in the corpuscular theory, conceived, as Herschel says, by Newton, and called by his illustrious name. Men learnt from the "Principia" how to deal with the motion of small particles under definite forces. The laws of wave motion were obscure, and till the days of Young and Fresnel there was no second Newton to explain them. There is truth in Whewell's words ("Inductive Sciences," ii., Chap. X.): "That propositions existed in the 'Principia' which proceeded on this hypothesis was with many ground enough for adopting the doctrine." Young's view, already quoted, appears to me more just; and I see in Newton's hypothesis the first clear indication of the undulatory theory of light, the first statement of its fundamental laws.

Three years later (1678) Huygens wrote his "Traité de la Lumière," published in 1690. He failed to meet the main difficulty of the theory, but in other respects he developed its consequences to a most remarkable degree. For more than a century after this there was no progress, until in 1801 the principle of interference was discovered by Young, and again independently a few years later by Fresnel, whose genius triumphed over the difficulties to which his predecessors had succumbed, and, by combining the principles of interference and transverse vibrations, established an undulatory theory as a fact, thus making Newton's theory a *vera causa*. There is, however, a great distinction between the emission theory as Newton left it and Fresnel's undulatory theory. The former was dynamical, though it could explain but little; the particles of light obeyed the laws of motion, like particles of matter. The undulatory theory of Huygens and Fresnel was geometrical or kinematical; the structure of the ether was and is unknown: all that was needed was that light should be due to the rapid periodic changes of some vector property of a medium capable of transmitting transverse waves. Fresnel, it is true, attempted to give a dynamical account of double refraction, and of the reflection and refraction of polarised light, but the attempt was a failure; and not the least interesting part of Mr. L. Fletcher's recent book on double refraction ("The Optical Indicatrix") is that in which he shows that Fresnel himself in the first instance arrived at his theory by purely geometrical reasoning, and only attempted at a later date to give it its dynamical form. "If we reflect," says Stokes,* "on the state of the subject as Fresnel found it and as he left it, the wonder is, not that he failed to give a rigorous dynamical theory, but that a single mind was capable of effecting so much." Every student of optics should read Fresnel's great memoirs.

But the time was coming when the attempt to construct a dynamical theory of light could be made. Navier, in 1821, gave the first mathematical theory of elasticity. He limited himself to isotropic bodies, and worked on Boscovitch's hypothesis as to the constitution of matter. Poisson followed on the same lines, and the next year (1822) Cauchy wrote his first memoir on elasticity. The phenomena of light afforded a means of testing this theory of elasticity, and, accordingly, the first mechanical conception of the ether was that of Cauchy and Neumann, who conceived it to consist of distinct hard particles acting upon one another with forces in the line joining them, which vary as some function of the distance between the particles. It was now possible to work out a mechanical theory of light which should be a necessary consequence of these hypotheses. Cauchy's and the earlier theories do not represent the facts either in an elastic solid or in the ether. At present we are not concerned with the cause of this; we must recognise it as the first attempt to explain on a mechanical basis the phenomena observed. According to his theory in its final form, there are, in an isotropic medium, two waves which travel with velocities $\sqrt{A/\rho}$ and $\sqrt{B/\rho}$, A and B being constants, and ρ the density. Adopting Cauchy's molecular hypothesis, there must be a definite relation between A and B. A truer view of the theory of elasticity is given by Green in his Paper read before the Cambridge Philosophical Society in 1837. This theory involves the two constants, but they are independent, and to account for certain optical effects A must either vanish or be infinite. The first supposition was, until a few years since, thought to be inconsistent with stability; the second leads to consequences which in part agree with the results of optical experiment, but which differ fatally from those results on other points. And so the first attempt to construct a mechanical theory of light failed. We have learnt much from it. At the death of Green the subject had advanced far beyond the point at which Fresnel left it. The causes of the failure are known, and the directions in which to look for modifications have been pointed out.

Now I believe that the effort to throw any theory into mechanical form, to conceive a model which is a concrete representation of the truth, to arrive at that which underlies our mathematical equations wherever possible, is of immense value to every student. Such a course, I am well aware, has its dangers. It may be thought that we ascribe to the reality all the properties of the model, that, in the case of the ether, we look upon it as a collection of gyrostatic molecules and springs, or of pulleys and india-rubber bands, instead of viewing it from the standpoint of Maxwell, who hoped, writing of his own model, "that by such mechanical fictions, anyone who understands the provisional and temporary character of his hypothesis will find himself helped rather than hindered in his search after the true interpretation of the phenomena." Prof. Boltzmann, in his most interesting Paper on "The Methods of Theoretical Physics,"† has quoted these words, and has expressed far more ably than I can hope to do the idea I wish to convey.

The elastic solid theory, then, has failed, but are we therefore without any mechanical theory of light? Are we again reduced to merely writing down our equations, and calling some quantity which appears in them the amplitude of the light vibration, and the square of that quantity the intensity of the light? Or can we take a further step? Let us inquire what the properties of the ether must be which will lead us by strict reasoning to those equations which we know represent the laws of the propagation of light. These equations resemble in many respects those of an elastic solid; let us, then, for a moment identify the displacement in a light wave with an actual displacement of a molecule of some medium having properties resembling that of a solid. Then this medium must have rigidity or quasi-rigidity in order that it may transmit transverse waves; at the same time it must be incapable of transmitting normal waves, and this involves the supposition that the quantity A which appears in Green's equations must vanish or be infinite. To suppose it infinite is to recur to the incompressible solid theory; we will assume, therefore, that it is zero. Reflection and refraction show us that the ether, in a transparent medium such as glass, differs in properties from that in air. It may differ either (1) in density or effective density,‡ or (2) in rigidity or effective rigidity.

* "Report on Double Refraction," *Brit. Assoc. Report*, 1862, p. 254.

† *Phil. Mag.*, July, 1893.

‡ The equations of motion for a medium such as is supposed above can be written:

$\rho \times$ acceleration of ether $+ \rho' \times$ acceleration of matter $= \Sigma B \times$ function of ether displacements, and their differential coefficients with respect to the co-ordinates $+ \Sigma B' \times$ similar function for matter displacements.

The quantity ρ may be spoken of as the effective ether density, the quantities B as the effective elasticity or rigidity.

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The laws of double refraction and the phenomena of the scattering of light by small particles show us that the difference is, in the main, in density or effective density; the rigidity of the ether does not greatly vary in different media. Dispersion, absorption, and anomalous dispersion all tell us that in some cases energy is absorbed from the light vibrations by the matter through which they pass, or, to be more general, by something very intimately connected with the matter. We do not know sufficient to say what that action must be; we can, however, try the consequences of various hypotheses. Guided by the analogy of the motion of a solid in a fluid, let us assume that the action is proportional to the acceleration of the ether particles relative to the matter; and, further, that under certain circumstances, some of the energy of the ether particles is transferred to the matter, thus setting them in vibration. If such action be assumed, the actual density of the ether may be the same in all media; the mathematical expression for the forces will lead to the same equations as those we obtain by supposing that there is a variation of density; and since it is clearly reasonable to suppose that this action between matter and ether is, in a crystal, a function of the direction of vibration, the apparent or effective density of the ether in such a body will depend on the direction of displacement. Now these hypotheses will conduct us by strict mathematical reasoning to laws for the propagation, reflexion, and refraction, double refraction and polarisation, dispersion, absorption, and anomalous dispersion and aberration of light which are in complete accordance with the most accurate experiments. The rotatory polarisation of quartz, sugar, and other substances points to a more complicated action between the ether and matter than is contemplated above; and, accordingly, other terms have to be introduced into the equations to account for these effects. It will be noted as a defect, and perhaps a fatal one, that the connection between electricity and light is not hinted at, but I hope to return to that point shortly.

Such a medium as I have described is afforded us by the labile ether of Lord Kelvin. It is an elastic solid or quasi-solid incapable of transmitting normal waves. The quantity A is zero, but Lord Kelvin has shown that the medium would still be stable provided its boundaries are fixed, or, which comes to the same thing, provided it extends to infinity. Such a medium would collapse if it were not held fixed at its boundaries; but if it be held fixed, and if then all points on any closed spherical surface in the medium receive a small normal displacement, so that the matter within the surface is compressed into a smaller volume, there will be no tendency either to aid or to prevent this compression, the medium in its new state will still be in equilibrium, the stresses in any portion of it which remains unaltered in shape are independent of its volume, and are functions only of the rigidity and, implicitly, of the forces which hold the boundary of the whole medium fixed. A soap film affords in two dimensions an illustration of such a medium; the tension at any point of the film does not depend on the dimensions; we may suppose the film altered in area in any way we please—so long as it remains continuous—without changing the tension. Waves of displacement parallel to the surface of the film would not be transmitted. But such a film, in consequence of its tension, has an apparent rigidity for displacements normal to its surface: it can transmit transverse waves with a velocity which depends on the tension. Now the labile ether is a medium which has, in three dimensions, characteristics resembling those of the two-dimensional film. Its fundamental property is that the potential energy per unit volume, in an isotropic body, so far as it arises from a given strain, is proportional to the square of the resultant twist. In an incompressible elastic ether, this potential energy depends upon the shearing strain. Given such a medium—and there is nothing impossible in its conception—the main phenomena of light follow as a necessary consequence. We have a mechanical theory, by the aid of which we can explain the phenomena; we can go a few steps behind the symbols we use in our mathematical processes. Lord Kelvin, again, has shown us how such a medium might be made up of molecules having rotation in such a way that it could not be distinguished from an ordinary fluid in respect to any irrotational motion; it would, however, resist rotational movements with a force proportional to the twist, just the force required; the medium has no real rigidity, but only a quasi-rigidity conferred on it by its rotational motion. The actual periodic displacements of such a medium may constitute light. We may claim, then, with some confidence, to have a mechanical theory of light.

But nowadays the ether has other functions to perform, and there is another theory to consider, which at present holds the field. Maxwell's equations of the electromagnetic field are practically identical with those of the quasi-labile ether. The symbols which occur can have an electromagnetic meaning; we speak of permeability and inductive capacity instead of rigidity and density, and take as our variables the electric or magnetic displacements instead of the actual displacement or the rotation. Still, such a theory is not mechanical. Electric force acts on matter charged with electricity, and the ratio of the force to the charge can be measured in mechanical units. A fundamental conception in Maxwell's theory is electric displacement, and this is proportional to the electric force. Moreover, its convergence measures the quantity of electricity present per unit volume; but we have no certain mechanical conception of electric displacement or quantity of electricity, we have no satisfactory mechanical theory of the electromagnetic field. The first edition of "Electricity and Magnetism" appeared twenty years ago. In it Maxwell says: "It must be carefully borne in mind that we have made only one step in the theory of the action of the medium. We have supposed it to be in a state of stress, but we have not in any way accounted for this stress or explained how it is maintained. This step, however, appears to me to be an important one, as it explains by the action of consecutive parts of the medium phenomena which were formerly supposed to be explicable only by direct action at a distance. I have not been able to make the next step, namely, to account by mechanical considerations for these stresses in the dielectric." And these words are true still. But for all this, I think it may be useful to press the theory of the quasi-labile ether as far as it will go, and endeavour to see what the consequences must be.

The analogy between the equations of the electromagnetic field and those of an elastic solid has been discussed by many writers. In a most interesting Paper on the theory of dimensions, read recently before the Physical Society, Mr. Williams has called attention to the fact that two only of these analogies have throughout a simple mechanical interpretation. These two have been developed at some length by Mr. Heaviside in his Paper in *The Electrician* for January 23, 1891. To one of them Lord Kelvin had previously called attention ("Collected Papers," Vol. III., p. 450). Starting with a quasi-labile ether, then, we may suppose that μ, the magnetic permeability of the medium, is $4\pi\rho^*$, where ρ is the density, and that K, the inductive capacity, is $1/4\pi B$, B being the rigidity, or the quasi-rigidity conferred by the rotation.

The kinetic energy of such a medium is $\frac{1}{2}\rho(\dot{\xi}^2+\dot{\eta}^2+\dot{\zeta}^2)$, where $\dot{\xi}$, $\dot{\eta}$, $\dot{\zeta}$ are the components of the displacement. Let us identify this with the electromagnetic energy $(\alpha^2+\beta^2+\gamma^2)8\pi$, α, β, γ being components of the magnetic force, so that $\alpha=\dot{\xi}$, $\beta=\eta$, $\gamma=\zeta$. Then the components of the electric displacement, assuming them to be zero initially, are given by

$$f=\frac{1}{4\pi}\left(\frac{d\dot{\zeta}}{dy}-\frac{d\dot{\eta}}{dz}\right), \text{ \&c.;}$$

that is, the electric displacement $\mathfrak{D}$ multiplied by 4π is equal to the rotation in the medium. Denote this by Ω.

The potential energy due to the strain is

$$\tfrac{1}{2}B\Omega^2, \text{ or } \tfrac{1}{2}16\pi^2 B\mathfrak{D}^2,$$

and on substituting for B this becomes

$$\frac{1}{2}\frac{4\pi}{K}\mathfrak{D}^2,$$

which is Maxwell's expression for the electrostatic energy of the field.

Thus, so far, but no farther, the analogy is complete; the kinetic energy of the medium measures the magnetic energy, the potential energy measures the electrostatic energy. The stresses in the ether, however, are not those given by Maxwell's theory. In the other form of the analogy we are to take the inductive capacity as $4\pi\rho$ and the magnetic permeability as $1/4\pi B$. The velocity measures the electric force, and the rotation the magnetic force, so that electrostatic energy is kinetic, and magnetic energy potential. Such an arrangement is not so easy to grasp as the other. Optical experiments, however, show us that in all probability it is ρ, and not B, which varies, while from our electrical measurements we know that K is variable and μ constant; hence this is a reason for adopting the second form. In either case we look upon the field as the seat of energy distributed per unit of volume according to Maxwell's law. The total energy is obtained by integration throughout the field. Now, we can transform this integral by Green's theorem to a surface integral over the boundary, together with a volume integral through the space; and the form of these integrals shows us that we may look upon the effects, dealing for the present with electrostatics only, as due to the attractions and repulsions of a certain imaginary matter distributed according to a definite law over the boundary and throughout the space. To this imaginary matter, then, in the ordinary theory we give the name of Electricity. Thus an electrified conducting sphere, according to these analogies, is not a body charged with a quantity of something we call electricity, but a surface at which there is a discontinuity in the rotation impressed upon the medium, or in the flow across the surface, for in the conductor a viscous resistance to the motion takes the place of rigidity. No permanent strain can be set up.

From this standpoint we consider electrical force as one of the manifestations of some action between ether and matter. There are certain means by which we can strain the ether: the friction of two

* If we adopted Mr. Heaviside's rational system of units, the 4π would disappear.

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dissimilar materials, the chemical action in a cell are two; and *when, adopting* the first analogy, this straining is of such a nature as *to produce* a rotational twist in the ether, the bodies round are said to be *electrified*; the energy of the system is that which would arise from the presence over their surfaces of attracting and repelling matter, attracting or repelling according to the inverse square law. We falsely assign this energy to such attractions instead of to the strains and stresses in the ether. Such a theory has many difficulties. It is far from being proved; perhaps I have erred in trespassing on your time with it in this crude form. The words of the French *savant*, quoted by Poincaré, will apply to it: "I can understand all Maxwell except what he means by a charged body." It is not, of course, the only hypothesis which might be formed to explain the facts, perhaps not even the most probable. For many points the vortex sponge theory is its superior. Still, I feel confident that in time we shall come to see that the phenomena of the electromagnetic field may be represented by some such mechanism as has been outlined, and that confidence must be my excuse for having ventured to call your attention to the subject.

ELECTRICAL ACTION OF LIGHT UPON SILVER.*

BY COL. J. WATERHOUSE.

More than half a century ago, in 1839, Edmond Becquerel was the first to show that the electrical action accompanying the chemical changes brought about by the influence of light upon various substances, including the silver haloids, could be observed with a delicate galvanometer. He found that this action was quite independent of any heating of one electrode more than another, but was powerfully affected by the different rays of the spectrum, the greatest action being produced by the violet, indigo and blue rays, while with the green, yellow and red rays there was little or no action. To observe these effects he used a covered vessel divided into two parts by a thin membrane. In each of the compartments he placed a plate of platinum or gold, previously made red-hot to remove all impurities, the plates being connected with the poles of a very sensitive galvanometer, and laid horizontally in the apparatus. Each compartment had a movable cover. He found that when the two compartments contained an alkaline solution, the plate exposed to the solar rays took negative electricity, while the reverse occurred if the solution were acid. When two silver plates were immersed in water acidulated with nitric acid exposure to light of one plate only produced a very weak current and the exposed plate was always positive. He found that when silver halide, precipitated in a thin layer on sheets of platinum or gold, was exposed to light, the exposed plate was positive, and that the initial action was much stronger with the bromide than with the chloride. With the iodide the current was almost as strong as with the chloride, but did not remain constant so long. When plates of silver were employed, instead of platinum or gold, as a support for the haloids, the effects noted were stronger and more regular, but it was found that the direction of the current depended on the thickness of the films; with thin coatings the exposed plate was positive, and with thick coatings negative. On the basis of these experiments Becquerel invented his electro-chemical actinometer, which was practically a voltaic element or cell composed of two plates of very pare silver coated with the violet subchloride of silver and plunged into a conducting fluid composed of two parts of monohydrated sulphuric acid in 100 parts of water. When diffused daylight or sunshine acted upon one of the plates, more or less deviation of the needle was observed which remained constant so long as the light remained of the same intensity and the surface was sufficiently sensitive. If the light was shut off, the needle returned to zero or somewhat beyond it, but soon regained its original position. The deflections of the needle could not, however, be considered as proportional to the intensity of the chemical action.

At the meeting of the British Association in 1880, Prof. G. M. Minchin gave an account of his experiments on the generation of electric currents by the action of light on silver plates which were coated with emulsions of bromide, chloride, iodide, and other salts of silver in gelatine and collodion, as well as with eosine, fluorescine, and various aniline dyes, the object of these experiments being the solution of the problem of producing a photographic image of an object at a distance. He found that when two pieces of clean silver foil attached to glass plates were coated with an emulsion of chloride of silver in collodion, and immersed in distilled water containing a few grains of common salt, the plates being connected with the terminals of a Thomson's galvanometer, and one of them screened from the light, that on exposing the unscreened plate there was an electric current produced, and the exposed plate was *negative* to the unexposed. When the plates were coated with iodide of silver in collodion by the wet silver-bath method, the liquid being water containing a little potassium iodide, there was a reversal of the nature of the exposed plate, it being *positive* to the unexposed.

In carrying out my experiments I have used two kinds of cells, one horizontal and one vertical, more usually the latter. It consists of a glass cell in which the plates can be coupled face to face or back to back, one being screened from light by the other and by one or two interposed screens of ruby or yellow glass, the cell being covered all round except at an opening on one side. This glass cell is enclosed in a wooden box with a shutter on one side sliding in front of an opening about 1·5in. × 0 5in., corresponding to the one in the glass cell. In front of this shutter there are grooves in which coloured glasses can be placed in front of the opening. The upper part of the wooden case is open, but can be closed by a lid, through which, if necessary, a funnel may be passed to admit of solutions being poured into the cell without letting in light.

As a rule my observations with coloured glasses or the spectrum have agreed with Becquerel's and Minchin's, that no reversal of sign is produced by any of the coloured rays. At the same time, I have found that in some cases the blue rays appear to have a reversing tendency, as might be anticipated from their very strong reversing action on certain forms of sensitive photographic plates containing iodide or bromo-iodide of silver.

The action of dilute sulphuric acid upon silver plates under the influence of light seems to be rather irregular, but I find that in nearly all cases the first exposed plate of each pair had a negative tendency when first exposed, though it might become positive by subsequent exposures, and in the same way the second plate of the pair, which was screened during the first exposure, might also be positive on first exposure. The general tendency was undoubtedly positive. In one experiment, however, the exposed plate was distinctly and uniformly negative, even after the position of the plates had been reversed, but subsequent exposure of the reversed plate made it positive. In another it was negative on first exposure and then positive.

With nitric acid the exposed plates are nearly always positive, and the action is far more uniform than with sulphuric acid. With distilled water acidified with about one drop of acid in 70cc., the exposed plate was positive on first exposure, but afterwards became negative. With dilute phosphoric acid the deflections were almost always positive. With 1 per cent. of hydrochloric acid, *sp. g.* 1·150, in distilled water, the exposed plates have shown themselves uniformly positive, and owing to the formation of a deposit of chloride they are much more sensitive to light. With dilute hydrobromic acid containing 10cc. of the ordinary dilute acid to 100cc. distilled water, the plate exposed to sunshine or diffused daylight was uniformly *negative* and extremely sensitive to light.

With a solution of 1 per cent. of caustic potash in distilled water, exposure to bright sunshine gave a deflection, the exposed plate being positive.

* Abstract *Journal* Asiatic Society of Bengal. Vol. LXII., Part II., No. 1, 1893.

ADDENDUM TO NOTE ON THE NATURE OF DEPOLARISERS.*

BY PROF. HENRY E. ARMSTRONG.

I am induced to somewhat extend my recent note† on depolarisers in order that the argument there made use of in considering the dissolution of metals such as magnesium in nitric acid may be clearly understood and its consequences more fully realised.

It is one of the most noteworthy features of such interactions that when reduction is carried beyond the nitric oxide stage, it invariably proceeds to ammonia, and gives rise to a variety of products; so that whereas neither nitrous oxide nor nitrogen is evolved when metals such as silver and mercury are dissolved, these two gases are always obtained when more active metals are the agents. From this it would appear that there is a limit of (?) E.M.F. which must be exceeded if it be desired to extend the reduction beyond the stage involving the formation merely of nitrogen dioxide and monoxide.

A somewhat similar case is presented by the behaviour of sulphuric acid solutions on electrolysis. Whereas, under certain conditions, besides hydrogen, only oxygen is obtained, under others ozone, persulphuric acid and hydrogen peroxide are also produced. This apparently is a phenomenon of the same order, but in a measure the converse of that presented by nitric acid, as oxygen—not hydrogen—is the active substance. Judging from McLeod's observations (*C.S. Trans.*, 1886, 591), it is clear that "current

* From the *Proceedings* of the Chemical Society.

† See *The Electrician*, June 30th, p. 229.

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density" is an all-important factor in determining "peroxidation," but it remains to be determined whether it is the sole factor. The individual influence of E.M.F., of current strength and of current density; in fact, all require careful study in this as in many other cases of electrolysis; undoubtedly much depends on the concentration of the acid. The peroxidation may be regarded as the outcome of oxygen depolarisation, effected apparently in two ways; part of the oxygen becoming affixed to sulphuric acid, persulphuric acid is formed, which in part gradually undergoes hydrolysis, affording hydrogen peroxide—a non-electrolytic change; while another part serves as oxygen depolariser, affording ozone. On this assumption, ozone is not the product of the fortuitous concourse of three oxygen atoms but of the interaction of oxygen atoms in circuit with persulphuric acid; and if this be the origin of electrolytic ozone, it appears not improbable that the oxidation of phosphorus, which is attended by the formation of ozone, will also be found to involve the formation of a peroxide hitherto undiscovered.

In the case of a metal such as magnesium dissolving in considerable excess of nitric acid, if a plate be imagined to be undergoing attack and conversion into nitrate at any one point, the displaced hydrogen may, it would seem, "travel along" a very large number of paths to other points on the plate capable of acting as negative pole and of there meeting with nitric acid in sufficient amount to oxidise it; and it is scarcely conceivable, therefore, that it should escape if the nitric acid act directly as depolariser. It is also difficult to understand why one substance, an electrolyte, should act in two ways in the same circuit, and the difficulty appears to be equally great whether any form of Grothus's hypothesis, or a dissociation hypothesis, be adopted in explanation of electrolysis. But these difficulties seemingly disappear if—as previously suggested—the active depolariser be a nitrous compound or derivative; perhaps, at all events, at the initial stage, nitrogen dioxide. Moreover, it would appear to be possible in this manner to account also for the extension of the reduction to ammonia; in the case of a metal like silver the amount of depolariser must always tend to reach a maximum value depending on the extent to which the reversible interchange expressed by the equation $NO+2HNO_3=3NO_2+OH_2$, is limited by the concentration and temperature; but it is limited by these conditions alone. In the case of more active metals, it appears probable that the nitric oxide also functions as depolariser, and is reduced to hydroxylamine and ultimately to ammonia. If such an action take place, it follows (from Ohm's law) that the more active the metal the more rapidly will hydrogen be displaced by it, giving greater opportunity, therefore, for nitric oxide to undergo reduction and leading to the production of an increased proportion of products of extended reduction. Any circumstance which would tend to diminish the proportion of nitrogen dioxide relatively to monoxide present in solution would, therefore, promote the formation of such products, and, in point of fact, Acworth and I have noticed, even in the case of copper, that when the metal is dissolved in diluted nitric acid, it appears to be more "active," *i.e.*, to furnish a larger proportion of products of extended reduction, than when more concentrated acid is used: as the presence of water must obviously favour the reversal of the interchange expressed by the equation $NO+2HNO_3=3NO_2+H_2O$, so that weaker would potentially contain a larger proportion of monoxide than stronger solutions of nitric acid, these observations would appear to be in harmony with the hypothesis here advocated. There is no evidence, be it remarked, that hyponitrous acid can be formed in acid solution, *i.e.*, by direct reduction of nitric or even of nitrous acid, and the whole of the nitrous oxide which is evolved when metals are disolved in nitric acid may result from the interaction of nitrous acid and hydroxylamine. That reduction invariably extends to ammonia whenever hydroxylamine is formed is probably a consequence of the extreme readiness with which hydroxylamine is itself reduced, so that, in fact, when reduction once proceeds beyond the nitric oxide stage, it is to be supposed that there are necessarily a number of competing depolarisers present in solution—nitrogen dioxide and monoxide and hydroxylamine (and perhaps others), none of which, however, are electrolytes in the sense in which the term is ordinarily understood. And here it may be pointed out that the fact that a nitrate may be reduced in alkaline solution by sodium amalgam, or aluminium, or zinc is no argument against the conclusion above arrived at, that probably nitric acid does not directly act as depolariser, as in these cases the alkaline solution appears to be the electrolyte, and the nitrate merely the depolariser—so that the nitrate does not act in two ways. As nitrates may be wholly converted into ammonia by reducing an alkaline solution, it would seem probable that in such cases hydroxylamine is not an intermediate product, as nitrogen is obtained on boiling an alkaline solution of this substance.

The argument here made use of would appear also to afford an explanation of the effect produced by varying the E.M.F., *i.e.* by metals of different degrees of "activity"; as increase of E.M.F., other conditions remaining unchanged, would increase the current strength and consequently the rate of change; and, as indicated above, an increase in the rate of change would doubtless involve an increase in the amount of products of extended reduction.

It remains to be pointed out that the objection made to the assumption that nitric acid can act in two ways is equally applicable to the case of sulphuric acid; in other words, that it is not likely that sulphuric acid would act as electrolyte and as oxygen depolariser. It becomes necessary, therefore, to reconsider the manner in which solutions of this acid undergo electrolysis. On the one hand it is conceivable that the water molecule alone suffers partition, not the sulphuric acid (H_2SO_4) molecule, as commonly supposed, and that under certain conditions the latter takes a direct part in the change, becoming oxidised; but this does not appear to be probable, especially as there is reason to believe that the acid in conjunction with water actually functions as electrolyte. An alternative assumption would be that the immediate product has been overlooked, and it can scarcely be gainsaid that there is much evidence in favour of this view. It is not improbable that the first products of electrolysis are hydrogen and *persulphuric* acid; it may be supposed that under "ordinary" circumstances this latter substance is resolved at the electrode surface into oxygen and sulphuric acid, but when the electrode surface is small much escapes unchanged, this being especially the case when the electrolyte is a somewhat concentrated acid—a condition which in itself favours the survival of persulphuric acid. Not only do recent observations on the electrolysis of various sulphates support this contention, but it would seemingly also serve to explain the extraordinary character of the curve representing the change in conductivity of solutions of sulphuric acid on dilution.

THE BRUSH-ADAMS ARC LAMP CLUTCH.*

Surrounding the Brush exhibit in Electricity Building at Chicago is a line of double carbon arc lamps whose steady burning is generally remarked. These lamps, though employing the clutch principle, so successfully applied by Brush, have a somewhat different arrangement for releasing the carbon from that originally employed. In the original form Brush, it will be remembered, employed the simple ring or washer, which encircled the carbon rod and the tilting of which, under the action of the magnets, allowed the carbon to feed, or held it in position. The lamps at present manufactured by the Brush Company, however, have a modified clutch arrangement, the joint invention of Mr. Brush and Mr. T. E. Adams, superintendent of the Brush lamp department. A glance at the accompanying illustrations will make clear the new arrangement.

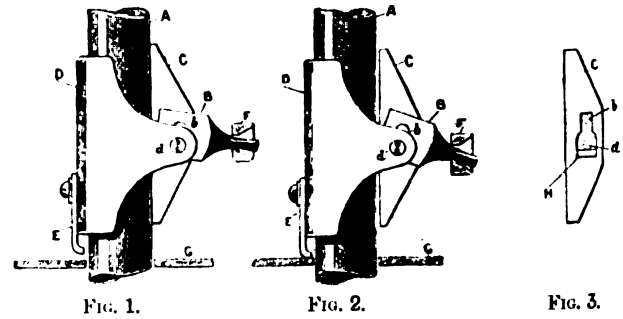

Fig. 1. Fig. 2. Fig. 3.

New Form of Clutch for Brush Arc Lamp.

Instead of the ring, a saddle, D, is employed, which is pressed against the rod by a shoe, C, both loosely pivotted in the clutch-lever B, which is acted by the arm F, which represents the end of the armature controlled by the regulating lamp magnets. Fig. 1 shows the position of the rods where the arc is sprung. As soon as the carbons burn away the weakening of the regulating magnets allows the armature, F, to drop, as shown (somewhat exaggerated) in Fig. 2, and releases the lamp rod just sufficiently to allow it to fall a slight amount; but just as soon as it reaches the point where the arc is of normal length the magnets are again energised and the clutch is applied, but at a point a little above its former position, where it is maintained until the carbons require readjustment.

The action of the clutch is imperceptible, and the feeding cannot be observed while the lamp is burning.

* From the *Electrical Engineer* of New York.

A Temporary Telegraph Line.—A temporary line of telegraph will be run up from Jamrud to Lundi-Kotal to facilitate communication with Kabul during the stay of the Durand mission in Afghanistan.

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CORRESPONDENCE.

THE NEW (?) INCANDESCENT ARC LAMP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I observe in your journal, as well as in the other technical papers, a description of "an improved arc light," which was described in a Paper read at Chicago by Mr. Marks. I always think it rather hard to see a device brought out as new which has already been carried out by oneself. In 1882 the very same lamp there spoken of I made and used, and only dropped the matter, finding that there was no great advantage to be gained, compared with little troubles which followed the new arrangement. To avoid the difficulties of passing the carbons through a closed globe I employed a Jablochkoff candle. The apparatus was made for me by Messrs. Baker, of Holborn, and finished off here, so that ample evidence exists of the facts I mention.—Yours, &c., DAVID L. SALOMONS.

Broomhill, Tunbridge Wells, Sept. 9, 1893.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

The 1893 Edition of "THE ELECTRICIAN" Electrical Trades' Directory and Handbook contains over 1,000 pages, several new and handy features having been added. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

The 1894 Edition is in preparation, and will be published, as usual, in January. New names, alterations of addresses, &c., are received at any time, but the Directory blanks and circulars are not sent out until later in the year, in order that the most recent, and consequently the *correct*, **addresses** *only* **shall appear in the book.**

TENDERS INVITED.—The Secretary of State for Foreign Affairs has received from Her Majesty's Ambassador at Madrid a copy of a Spanish Royal Order setting forth the conditions for the construction and laying of submarine telegraph cables uniting the islands of Luzon and Las Visayas, tenders for which are invited. The order can be seen on personal application at the Commercial Department of the Foreign Office between the hours of 11 and 6 daily.

——— The St. Pancras Vestry invite tenders for the extension of the buildings at their electric lighting station in Longford-street, which tenders must reach the Vestry Clerk by the 21st instant.

——— The Guardians of the Bristol Incorporation invite tenders for an electric light installation for certain portions of St. Peter's Hospital. Tenders must be in by the 21st inst.

——— The Gas Committee of the Leicester Corporation require tenders for the supply and erection of iron roofing for the electric lighting central station. Tenders must be in by the 23rd inst.

TENDERS RECEIVED.—Tenders have been received by the Bury Town Council from the following firms for the supply of the electric light plant for the central station:—Messrs. Mather and Platt (Limited), Manchester; Messrs. Laing, Wharton and Down, London; Messrs. C. A. Parsons and Co., Newcastle-on-Tyne; Manchester Edison-Swan Company, Manchester; Messrs. Johnson and Philips, Kent; Messrs. Siemens Bros. and Co. (Limited), London; India-Rubber, Gutta-Percha, and Telegraph Works Company (Limited), London and Silvertown; Woodhouse and Rawson (Limited), Manchester; Crompton and Co. (Limited), London; Brush Electrical Engineering Company (Limited), London; Messrs. J. H. Holmes and Co., Newcastle-on-Tyne; John Fowler and Co., Leeds (Limited).

TENDERS ACCEPTED.—The Dawlish Local Board have accepted the tender of Mr. James, of Exeter, to fit electric call bells to the houses of the firemen. A tender was also received from the National Telephone Company.

SALES BY AUCTION.—We would remind our readers that the sale by auction by Messrs. Furber, Price and Furber, of the valuable plant, machinery, and instruments of the London College of Electrical Engineering will take place on Tuesday and Wednesday next. Some further particulars will be found in our advertisement columns.

——— Mr. J. C. Stevens announces in our advertisement columns that he will sell by auction at 80 and 81, Turnmill-street, E.C., on Thursday next, the 21st inst., the manufacturing machinery and plant of the London Metallurgical Company (Limited).

FACTORY PREMISES TO LET.—Mr. R. A. Came, of 27, Mecklenburgh-square, W.C., has to let commodious factory premises in London.

PERSONAL.—Mr. Robert T. Turnbull requests us to announce that he resigned his position with the New Zealand Electrical Syndicate (Limited) and with the Gülcher (New) Electric Light and Power Company (Limited) on August 17th, and that he is now in business as a consulting electrical engineer at Custom House Quay, Wellington, New Zealand.

——— Mr. Horatio Bell, lately assistant engineer in the Glasgow district of the National Telephone Company, has been appointed engineer and manager of the Greenock district.

CHANGE OF ADDRESS.—Messrs. Babcock and Wilcox (Limited), notify that their address is now 127, Queen Victoria-street, E.C. instead of 114, Newgate-street, as formerly.

MESSRS. DORMAN AND SMITH.—Owing to increasing demand for their special manufactures, Messrs. Dorman and Smith are taking advantage of the termination of an existing agreement to place their London branch under the control of Mr. A. H. Dorman, who, in addition to attending to the London business, proposes to make periodical visits to the chief centres of the electrical industry, especially keeping in touch with the head office and works at Manchester.

LIQUIDATIONS.—At meetings of Abell's Electrical Engineering Company (Limited), held on August 14th and September 1st, resolutions were passed and confirmed that the Company be voluntarily wound up, and that Mr. F. W. Marsh, of Liverpool and St. Helen's, chartered accountant, be liquidator.

———The Registrar has appointed September 18th, at his chambers, Bankruptcy-buildings, Carey-street, W.C., for consideration of the determinations of the meetings of creditors and contributories of the London Metallurgical Company (Limited).

——— A meeting of the Automatic Standard Screw Company (Limited) will be held at Mr. T. England's, Town Hall-chambers, Crossley-street, Halifax, on October 13th, at 4 p.m., to receive an account of the winding-up.

——— Meetings of the creditors and shareholders of the International Electric Syndicate (Limited) were held on Wednesday, and, no resolutions being passed, the liquidation proceedings were left in the hands of the Official Receiver. Mr. Cully, assistant-receiver, stated that the Company was promoted in April, 1891, by Mr. Robert Williams Davey, who had absconded, and against whom bankruptcy proceedings were instituted last December. It appeared beyond doubt that there had been a considerable amount of fraud in connection with the Company's promotion. The patents acquired by the Company had not been traced, and a question would arise as to the proper ownership, as one of the vendors had repudiated the shares issued to him as consideration, and claimed a return of the patents. The attempts to trace Mr. Davey had also proved abortive, and, in his absence, no further steps could yet be taken.

BANKRUPTCY.—Selina Phillipine Annie Rowbottom, trading as S. Rowbottom and Co., electrical engineers, at 82, Abbey-street, Derby, has been adjudicated a bankrupt. The first meeting of creditors will be held at the Official Receiver's, Derby, on September 20th, at 12, and the public examination is fixed for October 11th at 2, at the County Hall, Derby.

LINE MATERIAL AND TRACTION APPLIANCES.—Mr. R. W. Blackwell, who is agent for Messrs. A. and J. M. Anderson, forwards us a comprehensive catalogue and price list of the "Anderson" line material and special appliances for electric tramways. The pamphlet deals with insulators, bracket arm hangers, single and double curve pull-offs, terminals, clamps, clips, ears, trolly pulleys and wheels, trolly bases, lightning arresters, wire stretching machines, &c., all of which are fully illustrated.

CHIMATTO ENAMEL.—We have received from Messrs. Fletcher, Russell and Co., of Warrington, a small cast iron gas boiler, the surface of which has been treated with "chimatto enamel." This process permits of an iron surface being given all manner of deli-

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cate tints, and is a decided improvement upon the shiny coating of Brunswick black which we usually associate with domestic iron work.

WRAY ELECTRICAL ENGINEERING COMPANY.—This Company have secured the contract for the erection of an electric light plant at the extensive cotton mills of Messrs. E. Heyworth and Son, Blackburn. The installation will consist of about 750 16-c.p. lamps, with separate slow speed vertical Robey engine, in combination with a direct-driven dynamo. The firm are also engaged on the wiring and fitting of the Mersey Rice and Flour Mill, Liverpool. This will be one of the largest electric light installations in corn mills in the North, and will consist of two 400-light dynamos and storage for 400 lights, together with a separate engine and dynamo for lighting the mill in the day-time.

MESSRS WOODHOUSE AND RAWSON UNITED (LIMITED).—Mr. F. D. Leslie, who is carrying on the above business on behalf of the debenture holders, reports a satisfactory increase in the amount of business done, and anticipates a full development as time goes on.

MESSRS. W. H. ALLEN AND CO.—The *employés* of the Belfast branch of Messrs. Allen and Co. held their annual outing last week. Warren Point was reached by train, and the party afterwards coached along the sea shore to Newcastle, where an excellent repast was enjoyed. Mr. Kempster, who responded to the toast wishing success to the firm, stated that over thirty steamers in Belfast had received complete equipments of electric lighting plants from that firm's works, in every case the utmost satisfaction being given to their clients. Mr. James McLelland, the Company's Belfast representative, and Mr. Wray, the superintending electrician, congratulated those present on the very cordial relations existing between the *employés* and the firm.

BANDON.—The Town Commissioners, at their meeting last week, resolved to carry out the recommendations of the ratepayers to reject the electric lighting scheme of the Bandon Electric Lighting Company.

BARROW.—At the last meeting of the Town Council it was resolved "that, in order to ascertain whether there is any demand for the electric light, a circular be sent to the householders in the centre of the town asking them to state whether they would be prepared to take a supply, and if so, to what extent."——Mr. R. Hammond gave a lecture upon the cost and utility of electricity in shops and houses on Thursday last week before the Barrow Naturalists' Field Club.

BOLTON.—The Gas Committee of the Corporation met on Friday to consider the revised tenders for the erection of the generating station and other buildings in connection with the scheme for lighting the town by electricity. They recommended the Town Council to accept separate tenders from local firms for the masonry, brickwork, joinery, slating, plumbing, &c., plastering, painting, and excavation work. The Corporation held a special meeting on Wednesday, and adopted the Gas Committee's recommendation.

DERBY.—The Town Council, at their last meeting, voted the Art Gallery Committee £109. 5s. 4d., to defray the cost of fitting up the Art Gallery with the electric light.

DUNDEE.—The Electric Lighting Committee have decided to instal the electric light in several of the streets of the city. 123 gas lamps are to be dispensed with, and in their stead will be erected 36 electric light pillars and lanterns.

EDINBURGH.—The large warerooms of Messrs. Adams and Son, Edinburgh, have recently been lighted by electricity by Mr. M. Buchan. A Crossley gas engine is used with a Royce alternating dynamo, in anticipation of accumulators being subsequently put in.

HASTINGS.—The Secretary of the Hastings Electric Light Company, having intimated that they were unable to obtain the necessary transformers for the extension of the electric light along the front by October 1st, the time fixed by the contract for the commencement of the lighting, the Town Council have agreed to the postponement until March 25th next of the beginning of the additional lighting.

HARROGATE.—A sub-committee reported to the Town Council on Friday that they had conferred with Mr. Wilkinson with reference to his appointment as electrical engineer to the Corporation, and had agreed with him as to the terms upon which he should prepare and carry out the installation in accordance with his report previously made. The sub-committee's report was approved.

HAWICK.—The Town Council had before them last week the question of lighting the town by electricity; but it was decided to defer taking any action in the matter until the ratepayers had had an opportunity of considering the question at the forthcoming ward meetings.

HUYTON-WITH-ROBY.—A letter was read at the last meeting of the Local Board from the British Insulated Wire Company, asking the Board's assistance in their obtaining a Provisional Order, to enable them to supply electric light within the Board's district.

LINCOLN.—The London and Provincial Brush Electric Lighting Company (Limited) having notified the City Council of their intention to apply to the Board of Trade for a Provisional Order to authorise them to supply electricity within the city, the Council have decided to oppose their application, as they themselves possess special facilities for lighting the city by electricity, and are quite prepared to undertake the work as soon as they are satisfied that it would be to the interest and advantage of the inhabitants to supply such a mode of lighting.

MERTHYR.—At the last meeting of the Local Board the Clerk said he had received a reply from the Pontypool Electric Light and Power Company in regard to the proposed electric lighting of Merthyr. The central station at Pontypool was not a large one, there being plant for the supply of 5,000 lights. The Company notified that they would be pleased to show any member of the Board over the station. The letter was referred to the Electric Lighting Committee for consideration.

MONTROSE.—At the meeting of the Town Council on Monday a long report was read from Mr. Wm. A. Bryson, of Glasgow, in reference to the suggestion that the electric light should be introduced into the town. In the course of his report, Mr. Bryson stated that he was strongly of opinion that it would neither be satisfactory nor economical to adopt water as the motor power. He, therefore, suggested the laying down of a small central lighting station with steam engines and boilers, or preferably gas engines and producers, the total cost of which he estimated would be £6,000, or if a large battery of accumulators was added the cost would be increased to £8,000. Details were also given as to the annual cost of maintenance, and Mr. Bryson works out a credit balance to the town of £352, and the price he estimates at 6d. per unit, equivalent to gas at 5s. per 1,000ft. It was agreed to let the report lie over until a future meeting.

NEWCASTLE.—On November 6th an Industrial, Electrical, Manufactures, and General Trades Exhibition is to be opened in St. George's Drill Hall, and will remain open until December 2nd.

NORWICH.—The electric light has just been installed in the United Free Methodist Church in Chapelfield-road, which is the first place of worship in the city that has availed itself of the new illuminant. The chapel itself is fitted with 46 16-c.p. lamps and 18 32-c.p. lamps. There are 4 16-c.p. lamps in connection with the organ, and 12 in the various class-rooms at the rear of the chapel; whilst in the porch there is a very elegant electrolier. The installation has been carried out throughout by Messrs. Laurence, Scott and Co.

SHEFFIELD.—At the last meeting of the Board of Guardians a letter was read from Mr. T. Scott Anderson, asking if the Guardians were disposed to consider the question of the electric lighting of the workhouse, but a resolution was passed that the Guardians could not consider the question at present.

SWINTON AND PENDLEBURY.—At the last meeting of the Local Board, the question of the advisability of the Board seeking a Provisional Order to light the district with the electric light was referred to a committee of the whole Board.

The Glasgow Municipal Telephone Scheme.—At last week's meeting of the Glasgow Town Council Mr. J. H. Martin raised the question of the telephones by saying that it seemed absurd to him to go on with the appointment of a telephone engineer when the committee had as yet only applied for a licence. Several members held that the committee had outrun their remit. Dr. Colquhoun said that if there was one thing clearer than another the step taken at the last meeting in authorising the committee to apply for a licence was a distinct indication that the telephone system in Glasgow was a matter which might very well be municipalised. Mr. Starke closed the discussion by saying that at the last debate he was asked, Where are your reports from experts? He had got reports at his own expense hitherto, and he could assure the Council that not a penny of expense would be incurred for an engineer, or an engineer employed before the licence was obtained, and that no engineer would be employed until the Committee came before the Council. At last the minutes were carried, subject to the understanding that no engineer would be employed until the licence had been obtained and the whole matter had again come before the Council.

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BOOKS RECEIVED.

"Numerical Examples in Practical Mechanics and Machine Design." By R. G. Blaine, M.E. (London: Cassell and Co) Price 2s. 6d.

"University College, Bristol." (London: Whittaker and Co.) Price 1s.

"Praktische Dynamokonstruktion." By Ernst Schulz. (Berlin: Julius Springer.)

"A. B. C. Logarithms." By C. J. Woodward, B.Sc. (London: E. and F. N. Spon.)

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published s compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

September 1st.

16,480. K. D. BOWEN. London. Improvements in or connected with electrically-propelled boats.

16,483. H. C. CHOCQUEEL. London. Improvements in and relating to electric switches.

16,484. H. H. LAKE. London. Improvements in self-starting alternating current electromotors. (F. H. Sleeper, Canada.)

September 2, 1893.

16,514. E. C. LACEY and W HABGOOD. London. Improvements in incandescent electric lamps.

16,562. B. WILLCOX. London. Improvements in electric motors. (E. R. Esmond, United States.)*

September 4, 1893.

16,571. I. A. TIMMIS. London. Improvements in signal, telegraph, or other posts.

16,594. A. R. UPWARD. London. Improvements in electrical means of advertising.

16,597. A. GENTZSCH. London. Improved inspissated oil for electrical insulating purposes, and method of producing same.

16,603. E. STÜTZ. London. Improved electric motor for punkahs.

16,630. B. KITTO and W. MUIR. London. Improvements in obtaining zinc from solutions by electrode position.

September 5, 1893.

16,699. W. PITT. London. Improvements in electric cranes.

16,702. E. S. and E. S. D'ODIARDI. London. Improvements in electro-coils for the administration of electricity to human beings, for medical purposes or others.

16,712. A. HALE. London. An improvement in or connected with medico-electric bands.

September 6, 1893.

16,746. G. J. DAVIS. London. Improvements in the design and manufacture of polarisation plates for electric apparatus, and frames or holders for same.

16,770. G. M. HAMLYN. London. Improvements in electrical connections to floating vessels, balloons, buoys, and the like.

September 7, 1893.

16,825. H. EDMUNDS. London. Improvements in the jointing or uniting of wires, rods, bars, or cables, more especially intended for jointing or uniting electric conductors.

16,836. W. P. THOMPSON. Liverpool. Improvements in or appertaining to incandescent electric lamps. (O. Berndt, Germany.)

September 8, 1893.

16,912. M. B. FIELD. London. Improvements in electric current meters.

16,923. C. E. PENISTON. London. Improvements in or relating to means or apparatus for preventing unauthorised persons overhearing private conversations by or through the telephone.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

14,533. LUCAS and NEW. Converting alternating currents of electricity into direct currents.

15,197. ANDREOLI. Electrolytic apparatus.

16,335A. HARRISON. Induction coils.

17,423. CHABEAULT. Supplying electricity to vehicles.

18,966. SIEMENS BROS. and Co. (LIMITED). (Siemens and Halske). Electrolytic decomposition of compounds of metals and sulphur.

19,212. OBLASSER and THÉRYC. Cases for electric batteries, &c.

1893.

4,910. JOSEPH. Electric switches.

4,911. JOSEPH. Electric lamp-holders.

4,912. JOSEPH. Electric lamps.

9,296. CRANEY. Electrolysis of salt.

9,965. LONGSDON. (Krupp.) Electrically working and welding metals.

11,369. GENTZSCH and OTHERS. Insulating compound.

11,579. THOMPSON. (Coffin.) Electrically welding metal.

13,489. ZEITSCHEL. Electric bell.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1893, pages 320-348, *&c., &c.*]

HARRISON, AINSLIE AND CO. (LIMITED).—This Company has been registered with a capital of £100,000, in £10 shares, to incorporate as a limited company the business of ironfounders, iron merchants, ironmasters, smelters, and steel converters, hitherto carried on by Messrs. Harrison, Ainslie and Co.

ANDERSON, ANDERSON AND ANDERSON (LIMITED).—This Company has been registered, with a capital of £50,000, divided into 1,000 Six per Cent. Cumulative Preference and 4,000 Ordinary shares of £10 each respectively, to acquire the goodwill of the business carried on in London, Bow, Bristol, and Cardiff, under the style of Anderson, Anderson and Anderson.

CHEMICAL AND ELECTROLYTIC SYNDICATE (LIMITED).—This Company has been registered with a capital of £30,000, in £5 shares, to acquire certain patents from Messrs. Lyte and Prof. G. Lunge (of Zürich) connected with the manufacture of bleaching powder, caustic soda, white lead, &c., and to carry on the business of manufacturing chemists, electro-chemists, druggists, bleachers, &c. The first Directors are N. H. Fenner, W. E. B. Blenkinsop, W. MacNab, and H. R. Baynes.

PRINTING TELEGRAPH AND CONSTRUCTION COMPANY OF THE AGENCE HAVAS (LIMITED).—The first return of this Company made up to June 28, 1893, has been filed, when the whole nominal capital of £115,000, in shares of £5 each, was subscribed for; 10,823 of these shares were issued as fully paid, while a call of £2 per share has been made on the remaining 12,177 shares. The calls paid amount to £5 400. 10s., leaving no less than £18,953. 10s. in arrears.

PROVINCIAL ELECTRIC LIGHT AND POWER SUPPLY (LIMITED) and PUTNEY AND HAMMERSMITH ELECTRIC LIGHT AND POWER SUPPLY (LIMITED).—In reply to official inquiries respecting the status of these Companies, V. B. D. Cooper states that no business has been done, and the undertakings have been abandoned upwards of six months.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended September 10th were £751, as against £768 for the corresponding period of last year, being an decrease of £17. The total receipts for the half-year amount to £8,124, against £7,695 in the corresponding period of 1892, being an increase of £429.

CRYSTAL PALACE DISTRICT GAS COMPANY.—At the ordinary general meeting of the shareholders on Friday, the Chairman said that while the extraordinarily fine and hot weather had caused a decrease of 4·47 per cent. in the quantity of gas sold, the competition of the electric light and oil had made no difference to the Company.

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COMMERCIAL CABLE COMPANY.—A quarterly dividend of 1¾ per cent. has been declared, payable on the 2nd proximo.

WESTERN UNION TELEGRAPH COMPANY.—This Company has declared a quarterly dividend of 1¼ per cent.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended September 8, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £1,919.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Sept. 6.	Price Wednesday, Sept. 13.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 13. Highest	Lowest.
			TELEGRAPHS			£ s. d.			
£1,134,640	Stock	12/6	Anglo-American	50½ 51½	50 51	5 7 10	Jan. Apr., July, Oct.	50¾	..
£2,932,680	Stock	25/0	Do. Preferred	92⅛ 93⅛	92⅛ 91½	5 17 8	" "	93½	92½
£2,932,680	Stock	5/0	Do. Deferred	9¾ 10¼	9¾ 10¼	..	.. ..	10⅜	10
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	99 102	99 102	3 18 5	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11¾ 12¼	11½ 12	5 8 4	Mar., June, Oct., Dec.	12	11⅝
£36,400	£100	5%	Do. 5 per Cent. Bonds	99 103	99 103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107 111	107 111	4 10 1	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	127 132	127 132	5 6 1	April and October	..	..
16,000	10	8/0	Cuba Submarine xd	11 12	11 12	6 13 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent. xd	18 19	18 19	5 5 3	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2⅛ 3⅛	2⅛ 3⅛	4 11 5	April and October	3⅛	3 1/16
6,000	5	10%	Do. Preference 10 per Cent.	8⅛ 9⅛	8⅛ 9⅛	5 5 3	" "	..	..
60,710	20	3/6	Direct United States	11½ 11¾	11½ 11 3/4	5 19 2	Jan., Apr., July, Oct.	11¾	11⅝
400,000	10	5/6	Eastern	15 15½	15 15½	4 5 3	" "	15 1/16	15
70,000	10	6%	Do. 6 per Cent. Preference	16 16½	16 16½	3 12 9	" "	16⅜	16 1/16
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	111 114	111 114	3 10 2	May and November	113½	111½
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	106 109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15⅛ 15⅜	15⅛ 15⅜	4 11 1	Jan., Apr., July, Oct.	15⅜	15⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	110 113	110 113	3 10 10	February & August	110	..
£70 600	100	5%	Do. 5 p. c.(Austln. Gov. Sub.) Debs 1900	102 105	102 105	4 15 3	January and July	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb.,1900	100 103	100 103	4 17 1	" "	103⅜	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	100 103	100 103	3 17 8	February & August	103½	101
£200,000	£25	..	Do. 4% Mauritius Sub. Debs.	102 105	103 106	..	May and November	104½	..
180,227	10	4,0	Globe Telegraph and Trust	9⅝ 9⅞	9⅝ 9⅞	4 13 8	Jan., Apr., July, Oct.	9⅞	9 1/16
180,042	10	6%	Do. 6 per Cent. Preference	15⅛ 15⅜	15⅛ 15⅜	3 17 5	" "	15½	15⅜
150,000	10	5 0	Great Northern	19¾ 20⅛	19¾ 20⅛	4 4 2	Jan., April, and July	20⅛	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue xd	103 106	103 106	4 14 4	March & September	..	..
17,000	25	37/6	Indo-European	39 42	39 42	5 19 1	May and November	..	..
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	3 6 8	" "	..	..
£100,000	100	6%	Do. 6 per Cent Debentures xd	104 107	104 107	5 12 2	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4 per Cent. Guar. Debs.	100 103	100 103	3 17 8	..	102¼	..
11,802	8	4/0	Reuter's	4½ 5½	4½ 5½	..	April and October	..	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6 per Cent.	115 120	115 120	5 0 0	" "	..	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July	..	..
£260,900	100	5%	Do. 5 per Cent. Debentures xd	97 100	97 100	5 0 0	March & September	..	..
30,000	10	2/0	West Coast of America	2 3	2 3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	97 101	97 101	7 18 5	June and December	..	..
88,321	10	6d.	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 10¾	10½ 10¾	5 11 7	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	106 109	106 109	4 11 9	June and December	108½	..
64,242	15	4 6	Western and Brazilian	6½ 7	6½ 7	5 7 6	May and November	6¾	..
33,129	7½	4,6	Do 5 per Cent. Cumulative Preferred	5¾ 6½	5¾ 6½	..	..	5¾	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1¼ 1¾	1¼ 1¾	..	..	..	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	105½	103½
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	120 125	115 120	5 16 8	May and November	..	..
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds xd	100 103	101 104	5 15 5	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	2 3	2 3	..	..	..	..
224,850	10/0	3½d.	Consolidated Telephone Const. & Maintenance	1 1/16 1 5/16	1 1/16 1 5/16	..	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid) xd	5/16 7/16	5/16 7/16	7 18 2	Yearly	..	..
458,867	5	2/6	National	4 5/16 4 7/16	4 5/16 4 7/16	5 8 1	June and December	4 9/16	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14½ 15½	14½ 15½	3 17 5	" "	14½	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14 15	14 15	4 0 0	" "	14	..
90,950	5	2/0	Do. 5% Non-Cumulative 3rd Pref.	5¼ 5½	5¼ 5½	4 10 11	.. ..	..	..
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	111 113	111 113	3 19 8	January and July	113	111½
58,000	5	1/0	United River Plate	2 2⅛	2 2⅛	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	11 11½	11½ 11⅝	..	..	..	..
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½ 13	12½ 13	..	..	12 13/16	12⅝
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	.. ..	.. ..	..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
8,322	£5	..	House to House Electric	.. ..	.. ..	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	.. ..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4⅛ 4½	4½ 4½	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6 6½	6 6½	..	..	..	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6½ 6¾	6½ 7	2 17 2	..	6⅝	6⅜
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	102 105	104 107	4 13 6	June and December	105½	105
6,452	£10	..	Notting Hill Electric	5 6	5 6	..	..	..	..
19,980	£5	9½%	St. James' and Pall Mall	6½ 6¾	6½ 7	..	..	6¾	6 1/16
20,000	£5	7%	Do. 7 per Cent. Preference	8 8½	8 8½	4 2 4	..	..	..
59,900	5	1/6	Westminster Electric Supply (fully paid)	4⅜ 5⅛	4⅜ 5⅛	3 6 8	..	5 1/16	4⅜
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	2/1	Brush Electrical Engineering xd	2⅞ 3⅛	2⅞ 3⅛	..	..	3⅛	2⅞
75,000	2	6%	Do. 6 per Cent. Preference xd	2 2¼	2⅛ 2⅜	5 1 1	..	2 1/16	2⅛
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures xd	10 107	106 108	4 3 4	March & September	..	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	4 5	3½ 4½	..	January and July	..	..
12,139	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	1¾ 2¼	..	..	..	..
49,900	10	12/0	Electric Construction	1½ 1¾	1½ 1⅝	..	..	1⅝	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅝ ¾	⅝ ¾	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22½	22
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	102½	..
11,334	£10	6/4	International Okonite Ordinary	1 2	1 2	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/0 4/0	3/0 4/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	1½ 2½	2 2½	13 19 8	May and November	2⅜	..
37,350	12	12/0	Telegraph Construction and Maintenance	32 34	32 34	5 5 10	March and July	33½	33
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	January and July	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	¾%	City and South London Railway	35 37	35 37	1 13 9	May and November	..	..
37,500	£10	..	Liverpool Overhead Railway	5½ 5¾	6¼ 6¾	..	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 801.—Vol. XXXI. FRIDAY, SEPTEMBER 22, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

The proceedings in Sections A and G cannot be said to have materially contributed this year to the advancement of science, which is the confessed object of the British Association. While other Sections thrive and interest their members with accounts of actual discoveries and with important discussions, Section A is but the *rendezvous* of certain professors, who take this opportunity of interchanging a few ideas before the end of their vacations. Outsiders are permitted to listen to their confabulations, and to take a minor part in the proceedings. As the professors are fortunately among the first rank, most of their ideas are of interest to those who are concerned with physical and mathematical science. On rare occasions some recent research is communicated, and occasionally an important report; but, for the most part, we have to be contented with scraps of theory, a stray problem or two, *réchauffée* of old Papers, and descriptions of instruments employed on important researches, which are themselves communicated to other societies. But the advancement of science, if any, is quite accidental. The teaching of physics in schools seemed to have stirred up a good discussion. The reason is obvious: a very large proportion of the active members of the Section are engaged in educational work.

Of the electrical work done in Section G the less said the better. In an article on this subject in our contemporary, the *Engineer*, a fortnight ago, a quotation was made from *Nature*, and of this we repeat the first sentence. "Unless Section G sets its house in order the mechanical science of the British Association will become a by-word among engineers." A volume might be written on the subject indicated by the title of Mr. G. Kapp's Paper, but he concerned himself chiefly with multiphase intricacies. This might have attracted some attention eighteen months or two years ago, but most of us are tired of talking about multiphase problems. Mr. Snell's Paper, if not another attempt to whip a dead horse, was an endeavour to stimulate a torpid hack. Mr. W. B. Sayers has naturally experimented further with his armature winding, and sent in a few curves to illustrate them. Three indirectly electrical items come under our notice, two Papers by Mr. W. W. Beaumont, one confessedly an improvement on a last year's invention, and the report on graphical methods.

Many an ether has been born in Section A. It would be perhaps convenient to name them after their birthplaces. Thus we have the gyrostatic or Montreal ether, the turbulent-vortex or Manchester ether, and the double-concentric-insulated-spherical-won't-be-worried-by-a-circular-saw ether which may be more conveniently called the Nottingham ether. The British Association has really done something in affording opportunities for the flowering of these hardy annuals, which rarely put out blossoms worthy of adorning the proceedings of a serious scientific society.

During the discussion last Tuesday of a "Supplementary Note on the Ether," read by Prof. Lodge, an interesting point was raised as to the exact basis of distinction between the terms *electrical* and *mechanical* as applied to the interactions between ether and matter. Prof. Lodge seems to take the position that there is no mechanical action between these two forms of substance, and is thus driven to the conclusion that wherever any action between them is known or suspected to occur it must be referred to some electrical action for its explanation. In view of the apparent reluctance which Prof. Lodge showed, to give an exact definition of an electrical action, it must be rather difficult to follow him to any definite conclusion. The fact pointed out by the President of the section, that all optical phenomena are capable of mechanical explanation, must leave the matter still within the region of legitimate doubt.

At the meeting of the British Association at Edinburgh last year, Prof. Hele Shaw presented an elaborate report on the use of graphical methods in mechanical science. We alluded to it at the time, and recorded the brief discussion which took place. The report occupied no less than 159 pages, and though 98 of these were occupied by a bibliography, we found it impossible to give any abstract of it in these columns. Another report has been presented, and we print this week an abstract which has been prepared by the secretary. The report of last year gave a summary rather than a description of graphical methods, and it is hardly correct to say that the interpolation of plotted results was treated fully in it, as is suggested in the present report. Graphical methods have been excluded from educational mathematics, chiefly by reason of the vicious circle of teacher, scholarship, examination, scholar, teacher. It does not seem to attract attention from the band of reformers who meet under the name of the Association for the Improvement of Geometrical Teaching,

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and we must look to technical colleges and professors of engineering as, for example, Prof. Hele Shaw and Prof. Robert Smith, for the encouragement of this important subject. Meanwhile, as the present report states, on the continent of Europe not only have special courses of lectures been devoted to the teaching of graphic statics, but in both Europe and America the graphic solution of problems has received attention in nearly every engineering course of instruction.

A Paper which excited considerable interest at the first meeting of Section G was the one read by Mr. W. Worby Beaumont on "The Automatic Balance of Reciprocating Mechanism." Although dealing with a purely mechanical subject, and proposing a purely mechanical remedy for one of the ills to which a certain class of machinery is heir, yet there is much interest to electrical engineers in this Paper, from the fact that it proposes a remedy for vibrations such as so commonly occur in high-speed central-station engines, and which have led to such legal difficulties in the past. Proceeding on the optimistic principle that every evil is but good in disguise, Mr. Beaumont does not attempt to stop the vibration by balancing or by stiffening, but proposes to absorb it and make it contribute to the useful effect of the engine. The abstract of his Paper, which will be found in another column, does not explain how this bold system is to be applied in practice.

To have kept up the price of glow lamps at 3s. 9d. until their retail establishments closed on the evening of November 9th would have been a foolish proceeding on the part of the Edison and Swan United Company. Foreign lamps, and cheap ones, are sure to be offered, together with the perhaps half-hatched productions of inexperienced English makers. With the view of retaining as many of their old customers as possible, as well as to show what they can do at a more moderate price, lamps of 8, 10 and 25 candle-power were reduced yesterday to 1s. 9d. It is to be hoped that twelve months hence our central-station managers will not be repeating the lamentations recently indulged in by Herr Clarence Feldmann, electrical engineer to the Cologne municipality, in an address on "Artificial Sources of Light," delivered before the Rhineland and Westphalia Gas, Electricity, and Water Association. "The recent fall in the price of incandescent lamps," says Herr Feldmann, "does not appear to be by any means an unmixed blessing. When we consider what accuracy is required, what perfection in the filament, and how the light produced varies with the potential of the current, being approximately proportional to its sixth power, we see that it will now be more unsafe to rely upon the lamps being correctly adjusted to absorb the right quantity of current at the right potential. The limit of error has hitherto been about 2 per cent. either way, but with the new price, 1s. per lamp, it will hardly be possible to come nearer than 4 volts either way."

The surrender of the Postmaster-General to those importunate Members of Parliament who have demanded that the agreement of the Post Office with the National Telephone Company should be presented to the House of Commons before ratification, has been followed by the announcement that this document will not be laid on the table till November. The penultimate month of the year is, indeed, appropriate to the consideration of a question over which the Post Office and Parliament have succeeded in getting thoroughly befogged. The decision of the Postmaster-General to lay the agreement before the House of Commons in draft form, notwithstanding that a contrary decision was supported by a previous resolution of the House, points to the conclusion that he is excusably anxious to pass some of the odium of a bad bargain on to the gentlemen who are largely responsible for such a bargain being necessary. Up to the present all that we have been able to detect, beyond sound, in the utterances of the legislators who have been prominent in badgering the Postmaster-General, has been something suspiciously like a childlike desire to eat the cake and have it.

The financial position of the Postal Telegraph Service receives greater attention than usual in the Postmaster-General's Report for 1892-3, just issued. Not only is the general business stationary, but in some branches of it there are continued signs of serious decline. Notably is this the case in respect of foreign telegrams, which seem to have suffered a formidable check since the establishment of telephonic communication with the Continent, the receipts from which do not cover the loss. Probably more is due to a similar cause than appears in the report, as touching inland telegrams, which have steadily diminished as telephonic facilities have increased.

Some attempts have been made to stop the inordinate growth of free railway messages, the number of which has for years past been a sore affliction to the Telegraph service. The extravagant length of these franked messages is nothing less than scandalous; and the Postmaster-General would strengthen his demands considerably, we suspect, if he were to make public the nominal value of these free messages, with illustrative examples of how the railway people's average message increases in length while other people's decreases.

After a year of office Mr. A. Morley has discovered that the vote he gave in 1891 for a Parliamentary Committee to inquire into the grievances of telegraphists was founded on a misapprehension, and that any actual grievances remaining can be dealt with by himself alone. Probably if Earl Compton, who now champions the telegraphists' cause, were to succeed Mr. Morley he would make the same discovery—the discovery, namely, that it is easier to give voice to dissatisfaction than to give reasons for it. Earl Compton failed in this; but on the other hand, Mr. Morley fails also in trying to make light of it. That the aggregate amount paid for wages goes on increasing is no proof that the individual wages are sufficient, and that many hundreds of applicants are ready for any superior vacancy does not prove that its emoluments are adequate. Moreover, midst all this agitation amongst the subordinates, it must not be forgotten that in the opinion of many of the higher officials, the superior appointments in the Post Office are the worst paid of any in the public service.

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Some two months ago we gave a brief account of an electro-medical contrivance which had just been described before the Académie des Sciences by M. D'Arsonval, but neither the inventor's high standing in the ranks of electro-medical investigators, nor the decidedly original illustration accompanying his memoir, could induce us to employ that fatal monosyllable "new." Our caution has not, however, served us in good stead. The very next week it was our painful duty to have to confess that the instrument used by M. D'Arsonval to measure the high-frequency magnetic fields employed by him had been previously used by someone else for a somewhat similar purpose; and we are now assured by no less than three affidavits, respectively sworn to by "the best known constructor of scientific apparatus in England," by "a member of one of the most respectable printing firms in London, and by a retired member of Her Majesty's Indian Civil Service," that "the inventor and publisher of the supposed new mode of electric treatment recently described by M. D'Arsonval to the Académie des Sciences, which has created such an immense sensation, and suddenly made his name widely known throughout the world, is *not* M. D'Arsonval, but Prof. E. S. D'Odiardi." Be this as it may, Prof. D'Odiardi stated in his original account that "le courant continu ou à des interruptions rares est employé," whilst the whole object of M. D'Arsonval's device was to submit the unfortunate individual inside his cage to the action of *high-frequency* discharges.

Cable Interruption:

	Date of Interruption.
Pernambuco-Ceara	September 1st.

A New French Electrical Journal.—The ranks of the French technical press have received an addition in the shape of an electrical contractor's paper called the *Journal de l'Electricité.*

Pavia.—Signor Luigi Losio has applied for a concession to utilise the water-power of the Naviglio to the extent of 500 H.P. for industrial purposes and for the electric lighting of Pavia.

The Madras Tramways.—By an order dated August 15th, the Madras Government has granted to the Madras Electric Tramways Company the extension of six months asked for from April 6th.

Salford.—Mr. S. J. Smith, Local Government Board Inspector, held an inquiry on Tuesday last, relating to an application by the Salford Corporation for authority to borrow £50,000 for the purpose of electric lighting.

House of Commons Telegraph Business.—Some idea of the business transacted at the House of Commons Post Office may be gathered from the fact that, since the beginning of the present Session no fewer than 102,248 telegrams have been dealt with, as compared with 68,895 in 1891.

British Association Grants.—At the meeting of the General Committee of the British Association on Wednesday a grant of £25 was made to Prof. Carey Foster in connection with electrical standards, and one of £5 to Prof. Oliver Lodge in connection with his movement on behalf of a National Physical Laboratory.

Wakefield.—At a meeting of the Town Council on Thursday last week, the Chairman of the Sanitary Committee proposed a resolution directing that an application should be made on behalf of the Corporation to the Board of Trade for a Provisional Order to authorise the Corporation to supply the electric light. There was practically no opposition, all the members voting for the motion with one exception. Mr. Robert Hammond has been retained to advise the Corporation in the matter.

The Electrical and General Engineering College.—We have received the prospectus of this establishment, which offers instruction in ordinary engineering, general science, and workshop courses. Students are prepared for entering the City and Guilds of London Institute, Cooper's Hill, and other colleges. Further particulars may be obtained from the Principal, Mr. G. W. de Tunzelmann, Penywern House, 2 and 4, Penywern-road, London, S.W.

Proposed International Electrical Exhibition in Geneva in 1896.—Even Chicago does not appear to have damped some people's ardour in the matter of exhibitions, and it is just possible that the opening of the magnificent and unique water-works at Geneva in 1896 may be an inducement to many to submit to yet another of these inflictions. The promoters of the Geneva Exhibition hope to be able on the neutral ground of Geneva to hold a really international show, and not a more or less local repetition of the Frankfort Exhibition.

Electricity in Mines.—The Baker's Creek Gold Mine, in New South Wales, is amongst the latest mines which it is proposed to work and light by electricity, an agreement having been entered into with the Hillgrove and Armidale Water-Power Electric Company, by which the works are to be supplied with 100 H.P. from the proposed electric works to be constructed at the Gyra Falls, about four miles from the property. It is estimated that a saving of little short of £1,000 a year will by this means be effected in working the machinery and lighting the mines, and it is expected that the change will be made not later than March, 1894.

The Electrolytic Treatment of Sewage.—A system of disinfecting town sewage, somewhat similar to that in use at Brewsters (N.Y.), is now being tested by Messrs. Merryweather and Sons, specially with a view to dealing with the drainage of seaside towns. The idea is that of electrically treating sea water, and thereby effecting such chemical changes as to render it a powerful disinfecting solution. A portable "Squires" engine is being used, with a dynamo bolted to its carriage for supplying the electric current, and the new disinfectant is pumped into the sewers by the same engine, the firm's hydraulic sewer flushing apparatus being employed.

Paris Universal Exhibition, 1900.—A decree organising the proposed Paris Universal Exhibition of 1900 has been published in the French *Journal Officiel.* Accompanying the decree is a report by the Minister of Commerce, M. Terrier, explaining that the unprecedented scale on which the project is to be carried out, the difficulties which may arise in regard to the retention of some of the buildings on the Champ de Mars, and the means to be adopted for the conveyance of visitors, necessitate this early notification. M. Alfred Picard, who filled the office of *Rapporteur Général* for the 1889 Exhibition is appointed Commissary-General. He will be assisted by a Consultative Committee of 100 members.

Brazilian Telegraphic Business.—The Managing Director of the Western and Brazilian Telegraph Company, under date of September 15th, writes us as follows:—

> Sir,—With reference to a telegram purporting to have emanated from Buenos Ayres and addressed to the President of the Central and South American Telegraph Company, stating that the office of this Company at Rio Janeiro had been abandoned by the staff, permit me to inform you that this Company has two offices at Rio Janeiro, the one in the city which has been closed, being in the line of fire, and as its use was not permitted it was useless to subject the men to unnecessary risk; the other office, a short distance from the town, is out of the scene of operations, and has not been interfered with, thus when hostilities cease and we are permitted to recommence business, telegrams will be subject to no delay of any sort whatever. In the meantime, "through traffic" with the River Plate is not interfered with by our route.

——Under date September 20th, the Eastern and Brazilian Telegraph Companies notify that telegrams written in plain language and of a non-political character can be accepted for Brazil.

The Decimal System in the United States.—At an engineering Congress held at Chicago on August 1st last, which was attended by leading members of the profession from many countries, a Paper on the fundamental units of measure was read by Mr. T. C. Mendenhall, who is superintendent of the United States Coast and Geodetic Survey, as well as Superintendent of the Standard Weights and Measures at Washington.

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Mr. Mendenhall stated, *inter alia*, that the office of weights and measures at Washington, with the approval of the secretary of the Treasury, would in the future regard the international prototype metre and kilogramme as fundamental standards; and the customary units, the yard and the pound, would as from April 5, 1893, be treated as derived therefrom. This amounts to an official notification that the United States have formally adopted the metre as the standard of measurement. In future the yard will be represented as a fraction of the metre and the pound as a fraction of the kilogramme in the Washington office of weights and measures.

The Cost of the Chicago Exhibition.—According to the *Engineer* the Chicago Exhibition has cost $23,867,752 to August 7th for construction and administration. The gate receipts to the same date were $3,447,037, and receipts from concessions $1,178,546. The daily receipts from all sources are about $80,000, and the average daily expenses $15,000, leaving a net daily revenue of $65,000. Auditor Ackerman, in his condensed balance-sheet of July 31st, charges to construction account a total of $18,819,198; to general and operating expenses $4,957,879, and to preliminary organisation $90,674. Assuming that the Exhibition will remain open for 60 days from August 7th, this leaves a profit of about $4,000,000. Adding $4,600,000 previously received, we have a total net profit of $8,600,000, deducting this from the cost, we see that a balance of about $16,000,000, or nearly £3,000,000, remains to be met. The Chicago Exhibition represents the largest money loss that has ever been incurred by an Exhibition. The greater number of the Chicago hotels have gone into liquidation or been closed. The insurance companies have withdrawn their policies on several of the caravanseries especially constructed to accommodate a countless crowd of visitors who have never arrived. The insurance companies assert that in the interests of morality it is wrong to tempt the hotel keepers to commit arson, the average of visitors to these hotels being from 7 to 10 per cent. only of that expected and provided for. The visitors are, indeed, mostly country folk, coming from a radius of about 300 to 500 miles. Probably no other scheme introduced to the world with such a blowing of trumpets has, says our contemporary, ever fallen so flat.

Proposed British Association Arrangements for 1894 and 1895.—A meeting of the General Committee of the British Association was held at Nottingham on Monday for the purpose of determining upon the place of meeting the year after next. A deputation attended from Toronto and Prof. Mavor explained the facilities which Toronto afforded for the holding of general and sectional meetings. Sir Douglas Galton wished to know whether any additional facilities would be offered, such as those which were enjoyed by British members when the Association met at Montreal. Prof. Mavor was not prepared to say that the Dominion would, as on the former occasion, bear a portion of the cost of the passage-money of British members. It was moved by Sir Douglas Galton that the committee desired to express their best thanks to the Provisional Committee of Toronto for the invitation, and provided that suitable arrangements could be made similar to those that were made for the Montreal visit the committee would be prepared to entertain the question of meeting at Toronto before many years had elapsed. The conclusion of the resolution provoked some laughter. It was then put and agreed to. Deputations were then introduced from Bournemouth and Ipswich, the statement of whose rival claims afforded a good deal of amusement. On the question being put to the vote, there appeared 31 for Ipswich and 20 for Bournemouth. It was, therefore, decided that the meeting of 1895 should be held at Ipswich. On the motion of Sir Frederick Bramwell, seconded by Sir W. H. Flower, the Marquis of Salisbury was nominated President of the meeting next year at Oxford.

A Tasmanian Copper Mine.—In an article entitled "A 'Rio Tinto' for Tasmania," *The Statist* of last week dilates on a wonderful copper find in Tasmania. In metalliferous discoveries Australasia has, says our financial contemporary, been a land of surprises. It is a pretty well-known story now how a shepherd discovered the existence of silver, which has proved so abundant in the Broken Hill district in New South Wales. The Mount Bischoff tin deposits in Tasmania were a surprise, as also were the Mount Zeehan silver lead deposits in the same colony. But as regards the last-named colony there is yet another surprise, and one of very considerable interest, not to say importance. It would appear from the reports of unimpeachable experts that there is an immense copper deposit at Mount Lyell, near Zeehan. This deposit has been exploited by a colonially-formed Company. Apparently the deposit exceeds that of the well-known Tharsis Company; and though the Rio Tinto mine so called is a Goliath alongside the new Tasmanian property, so far as the copper deposits have been proved the Mount Lyell copper deposit we have referred to promises to be of very great commercial importance. The first consignment of about ten tons of ore was assayed in the colony as 1,054 ounces of silver to the ton and 20 per cent. of copper. The assay on which the sale was made, of the same quantity, was 1,250 ounces of silver and 26 per cent. of copper. One of the fortunate conditions as regards the position of the property is an immense water power—in one part a fall of 400ft., and in another part a fall of 1,000ft. The one, representing, in a dry season, 300 horse-power and the other over 2,000 horse-power. It is proposed to utilise this, the water-power being used to generate electrical power. Electricity will be applied as power for every mechanical purpose, and possibly also for producing refined copper, and separating at the same time the gold and silver. From what has actually been proved, it is estimated there are some 4½ million tons of ore accessible, to say nothing of what is believed, but has not yet been proved, to exist. One particular point about the new discovery is that apparently the deposits can be worked in a manner similar to the Rio Tinto deposits, that is, by terraces and cutting down the ore as from the side of a hill; in other words, bodily removing a portion of the side of a hill, the part removed consisting entirely of copper ore.

The Accident at the Blackfriars Transformer Sub-Station. An inquest was held at Guy's Hospital on Friday last by Mr. A. C. Langham, Deputy Coroner for Southwark, with reference to the death of Frederick William Ball, aged 35, of Alfred-street, Battersea Park-road, who was killed by an electric shock on the previous Tuesday afternoon. Major Cardew represented the Board of Trade.—Philip Hunt stated that on Tuesday night last week, about half-past six o'clock, he was called into the converter-house of the London Electric Supply Corporation, Blackfriars-road, where he found the deceased lying on the floor between two converters and a stool. He appeared to be dead. A young man named Meech was at the door very badly burned. The witness at once telephoned to one of the other stations for assistance. Witness was not employed by the Corporation, but he worked on the same premises.—John George Freeman, the engineer in charge of the London Electric Supply Corporation station at Blackfriars, stated that on receiving the telephone message for help he at once took a cab, and arrived at the Blackfriars station shortly after seven o'clock. Meech, the assistant linesman, was sitting on a stool, whilst Ball was lying on the ground dead, with outstretched arms, near transformer 42. The deceased had been in the Corporation's employment for a number of years. He was always a very careful man, and must have been aware of the danger he incurred when dusting with the plug in the omnibus bar.—Mr. P. W. d'Alton, engineer-in-chief to the London Electric Supply Corporation, said the deceased had the reputation of being an exceptionally careful, trustworthy man, and that he knew every bolt in the building. It was a piece of lamentable forgetfulness on his part not to have removed the plug before commencing to dust. Meech's duty required no previous knowledge of electricity. Notices, with "Dangerous" on them, were posted over the machinery.—Dr. Hamilton, house surgeon, said he saw the deceased between seven and eight on Tuesday evening. There was a ragged wound on the back of his right wrist and hand, and the flesh was charred and smelt of burning. There was also a smaller wound on the back of the left wrist, and the injuries had the appearance of having been caused through contact with electricity.—Other evidence showed that Meech had been very badly burned, and would not be able to leave the hospital for some time; and the inquiry was eventually adjourned for a month for his attendance.

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LANDMARKS IN THE HISTORY OF ELECTRO-CHEMISTRY.*

BY W. W. HALDANE GEE, B.SC., F.C.S.

(*Concluded from page 530.*)

l experimenters were greatly mystified by the evolution drogen and oxygen at a distance from each other during electrolysis of water. Some conceived the curious idea water is a simple substance, which, when positively rified, becomes oxygen, and when negatively electrified mes hydrogen. To others it appeared that the galvanic t was a peculiar acid, as appeared from its taste, its power eddening litmus, of oxidising metals, and of forming . The subject was further complicated by the observa- that the purest water yielded, on electrolysis, both acid alkali.

ery fortunate was it for electrical and chemical science there was at this critical time a philosopher prepared to on experiment rather than on conjecture. Davy had been

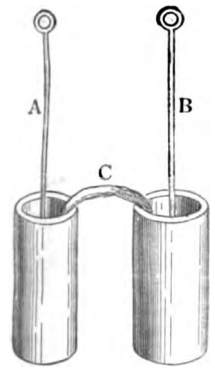

Fig. 6.

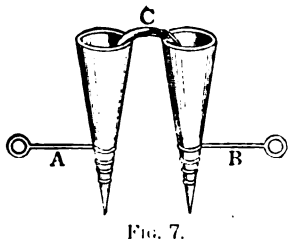

Fig. 7.

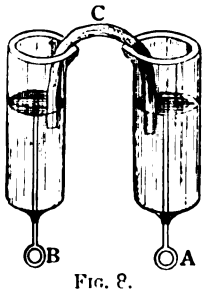

Fig. 8.

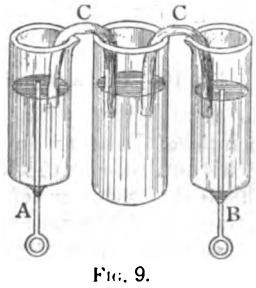

Fig. 9.

Figs. 6, 7, 8, and 9.—Apparatus used by Davy.

verfully impressed by the experiments of Carlisle and cholson. In it he perceived the connection of electricity l chemistry. His first paper on this line of work appeared September, 1800. It was followed in quick succession by others, in one of which he says: "But a short period has psed since philosophers beheld with wonder solid and fluid bstances assuming new modes of existence in different gases. not the new phenomena of galvanism authorise us to hope t at no very distant time they will behold even the gases dergoing novel changes and existing in new and unknown ms?" On his appointment at the Royal Institution, he de galvanism the subject of his first course of lectures, l it was likewise the subject of his first communication to the yal Society. Passing by his earlier work, those researches ich had such an important bearing on chemistry will be cribed.

Davy's first Bakerian lecture was devoted to the description his experiments on the fact above mentioned, that acid and ali are obtained during the electrolysis of water. Believing that glass vessels might yield some of their substance to the water, he first used small cups of agate (Fig. 6).

These were connected at C with very white and transparent asbestos. Pure water was placed in the cups, and the electric current passed. After 48 hours, it was found that one cup contained acid, and the other alkali. Thus the result was similar when agate cups were used to that with ordinary glass vessels. Being still unsatisfied, however, with regard to the question of the possible influence of the nature of the vessel, he repeated the electrolysis many times, using the same agate cups. With each repetition of the experiment it was found that although the amount of acid produced appeared not to have changed, yet the quantity of alkali steadily diminished. From this fact he concluded that the alkali was due to the abstraction of a constituent present in small quantity in the agate, this constituent being almost entirely removed by the end of his frequently repeated experiments. His next modification was the employment of vessels of a material entirely different in its chemical nature from either glass or agate. He constructed cups of gold of the form shown in Fig. 7.

On electrolysis alkali was again found, though in smaller quantity. Reflecting that the water used had been distilled from a *glass* retort, Davy purified the water for his experiment by distillation in a silver still. On electrolysing this water in the gold cups alkali was no longer found. He had then definitely shown that the alkali was due to contamination of the water, and had traced the source of this contamination. The acid, however, still appeared. On testing, he came to the conclusion that the acid produced was nitric acid, which he knew, from the experiments of Cavendish, to be produced from *air* by means of electricity. He devised a special apparatus for the electrolysis of water out of contact with air, collecting the gases formed. In this final experiment he showed that pure water electrolysed out of contact of air in an apparatus made of gold, is decomposed with the formation of the well-known gases, and of no other substance whatsoever.

After the completion of this model of scientific research, Davy turned his attention to the decomposition of solid bodies.

Two cups of compact sulphate of lime, treated by the method previously employed, gave sulphuric acid and lime. Various minerals, as lepidolite and zeolites, were decomposed in the same manner, and some interesting experiments were performed on the transference of substances during electrolysis. In these the glass apparatus shown in Figs. 8 and 9 was employed. Some of these experiments were extensions of those of Berzelius and Heisinger who, about the year 1803, observed the following laws:—(1) Oxygen and acids are accumulated round the positive pole, while hydrogen, alkalies, earths, and metals are accumulated round the negative pole; (2) Acids and bases may be made to pass through a considerable column of water, and even to cross each other in order to accumulate round the poles to which they are respectively attracted.*

Owing to the constant appearance of certain bodies at particular poles, the division of elements into electro-positive and electro-negative was suggested. It appeared as if any compound could be regarded as consisting of two parts, one electro-positive, the other electro-negative. Bodies with chemical affinity for each other were regarded as being in opposite electrical states, the energy of combination being proportional to the difference of electrical tension. Chemical affinity and electrical attraction were considered by Davy to have a common origin. The dualistic theory of Berzelius, a modification of that of Davy, has had an important influence on chemical theory.† The consideration of these early attempts at harmonising chemical and electrical facts are of peculiar interest at the present time, in the light of the recent advances due to the researches of Arrhenius, Ostwald, and others.

Davy was unremitting in his researches in the field of electro-chemistry. A year after the first Bakerian lecture he

The substance of these articles was originally read at a meeting of the ens College Chemical Society. For some help in preparing for publica- I am indebted to Mr. Vaughan Cornish, M.Sc., F.C.S.

* The Paper containing these experiments was first published by Gehlen in his Journal in 1803. It was afterwards published by Berzelius in Swedish in 1806. (*See* Thomson's "System of Chemistry," Vol. I., 1817. p. 175.)

†*See* Wurtz's "History of Chemical Theory," translated by Watts, p. 67

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published the discovery of potassium and sodium. In this work he used a combination of batteries, 274 plates in all. Connecting a platinum spoon with one end of the battery he fused in the spoon some caustic potash. On bringing a platinum wire connected with the other end of the battery into the fused potash some brilliant phenomena occurred. When the wire was connected with the negative pole a most intense light was emitted, and a column of flame, which seemed to be due to the development of combustible matter rose, from the point of contact. When the spoon was connected with the negative pole globules which inflamed in the air rose through the potash. Attempts were made to collect these globules, but without success until the happy device was hit upon of making the electric current the common agent for fusion and decomposition. Potash when dry is a non-conductor of electricity, but a slight addition of moisture gives it conducting power. A small piece of pure potash, moist on the surface from exposure to the atmosphere, was placed on a disc of platinum in connection with the negative side of the battery of 250 elements in a state of intense activity, and a platinum wire communicating with the positive side was brought to the upper surface of the alkali. A vivid action soon took place, and small globules of a high metallic lustre, like quicksilver, made their appearance. These were the sought-for "basis of potash." When Davy first saw the minute globules burst through the potash and take fire he could not contain his delight, but careered round the room in ecstacy.* At the Royal Institution may be seen his note-book in which his description of an improved method terminates with the words "a capital experiment."† This "capital experiment" was the commencement of a long and brilliant research. Soda soon yielded its "basis" to the same methods. A lengthy investigation of the properties of potassium and sodium followed. They appeared like the *alkahests* of the alchemists, imagined substances capable of acting upon everything with which they came in contact. The properties of these metals are familiar enough now, but it is not difficult to understand the intense interest which they excited at the time. The Bakerian lecture occupies 44 quarto pages, full of valuable preliminary results. Unfortunately, the work was interrupted by a dangerous illness.

During this illness of Davy the fame of his researches caused great interest and emulation in France, with which country England was then at war. The spirit of rivalry, perhaps, stimulated Napoleon to grant funds for the construction of a monster battery (*see* Fig. 10). "S. M. I. et R. desired that France should possess a pile stronger than any in existence, in order that it might be seen if elementary substances, which have hitherto remained undecomposed by ordinary means, would yield to an agent so powerful. In a short space of time a battery was constructed of 600 pairs of about 9 square decimeters area, together with others of a smaller size." (Gay-Lussac et Thenard: "Recherches Physico-Chimiques.")

Each pair of the great battery was composed of a copper plate of a kilogram weight, and another of zinc of a weight of three kilograms. The physiological effects were unbearable, and even dangerous, the effects of the shock being felt for several days. The battery decomposed potash and soda with great rapidity, the potassium and sodium burning, as they formed, with jets of fire like an artificial volcano. The action, however, soon ceased, and in twenty minutes the battery had run down. The great battery was not destined to be of much service to chemistry. The difficulty of obtaining potassium and sodium in any considerable quantity by electrical means was so great that Gay-Lussac and Thenard determined to try other methods. They finally adopted the process which still bears their names. These workers traversed very nearly the same ground as that gone over by Davy; their object being the same, viz.: the application of electricity to chemistry. If any spur had been needed to stimulate Davy on his return to health, it would have been supplied by the concurrent research of the French workers. In the opening lecture of the first course which he gave after his recovery, he said, "It will be seen that Volta has presented us with a key which promises to lay open some of the most mysterious recesses of nature. Till his discovery our means were limited, the field of pneumatic research had been exhausted, and little remained for the experimentalist except minute and laborious processes. There is now before us a boundless prospect of novelty in science, a country unexplored, but noble and fertile in aspect, a Land of Promise in philosophy." With undiminished enthusiasm he recommenced work. A voltaic battery of 600 double plates had been provided for him during his convalescence, and when it was thought necessary to have a battery of 2,000 plates it was constructed, the expense being met by subscription. The alkaine earths were subjected to the new method of analysis, with some success. Boracic acid was made to yield boron, whilst, on the other hand, the elementary nature of sulphur, phosphorus, and carbon was confirmed by their remaining undecomposed.

During the progress of these electro-chemical researches, Davy observed that charcoal intensely heated by galvanic agency was not acted on by oxymuriatic acid, not a trace of carbon monoxide, or of carbonic acid, being formed. This led him ultimately to proclaim that the substance discovered by Scheele, the nature of which as an oxidation product of muriatic acid had hitherto remained undoubted, was in fact an elementary substance, for which he proposed the name *chlorine*. This opinion, which traversed the position taken up by the French School of Chemists, was keenly debated, but the accumulation of experimental evidence showed conclusively that Davy's view was correct. As a consequence, the prevailing theory of the constitution of salts had to be modified.

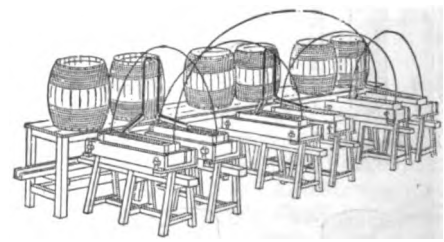

Fig. 10.—The battery of Gay-Lussac and Thenard.

The mantle of Davy as an electro-chemist descended upon Faraday, his successor at the Royal Institution. The isolated facts which the industry of experimentalists had collected between the years 1800 and 1830 he arranged in a philosophical system. He showed that electro-chemical deposition does not depend upon a direct attraction by the poles. The character of the bounding surfaces by which the current enters appears to be a matter of indifference when the liberated materials have no chemical action upon the poles. The poles are only the doors by which the current passes into or out of the decomposing body. The term *pole* had hitherto been applied only to metallic surfaces; a new word was therefore desirable, and Faraday proposed *electrode*. The terms anode, cathode, ion, anion, cation, electrolysis, and electrolyte were likewise coined by him. They were invented in order to obtain greater clearness in expressing his views on electro-chemical decomposition. An early result of his *electrolytical* researches was to learn that the liquid state is necessary for electrolysis. An instrument for measuring currents, *i.e.*, the *quantity* of electricity conveyed by a current, being needed, he invented the volta-electrometer, or, as it would now be termed, the voltameter. An exhaustive research showed him that the indications of the instrument were reliable under the most diverse conditions. Thus he proved that the form of the electrodes and the strength of solution were without effect upon its indications. Using these instruments, he was able to prove with respect to water what he calls the very extraordinary and important principle, that, when subjected to the influence of the electric current, a quantity of water is decomposed which is in every case exactly proportional to the quantity of electricity which has passed, notwithstanding every possible variation in the other conditions.

* *See* "Memoirs of the Life of Davy." By his brother, John Davy. Vol. I., p. 384.

† *See* "Life of Sir H. Davy." By Dr. Paris. Vol. I., p. 277.

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HORSE-POWER AND THE WATT.

While every elementary student, if not every school-boy, knows that the scientific world has been wrestling for years over the last decimal place or two in the value of the ohm, and while many over-conscientious young engineers use 3·1416 for the value of π in their calculations, everybody swallows 746 watts to the horse-power, as if nature had obligingly arranged that a convenient integral number should express the relation. As a matter of fact there is a small error of about one in ten thousand. The horse-power is, of course, 33,000 standard foot-pounds per minute, and the watt is 10^7 ergs per second. The former of these is a gravity measure of power; the latter a C.G.S., or "absolute" measure. It might at first sight be supposed that, this being so, the relation between the two units would have a geographical variation, inasmuch as g varies with latitude. In fact, we have met with otherwise excellent and reliable physical treatises in which this erroneous view is held; books which even give a table of the different numbers of watts in a horse-power at different latitudes. Now, although there is a perceptible difference in the work done in raising 33,000lb. one foot high at two different latitudes, the work in each case will not be the true measure of a horse-power at that place. The gravity unit of work is not the work done in lifting a pound one foot vertically at *any* latitude; but is defined to be the work which would be done by performing this operation at one definite place on the earth's surface, viz., at Greenwich sea-level. This difficulty is carefully avoided in the G.G.S. system by the device of an acceleration unit of work, instead of a gravitation unit. The number of watts in one horse-power is, then, always the same at whatever place on the earth's surface or interior the comparison may be made; but this number is not exactly 746. The force of gravity on one pound, at Greenwich sea-level, is found to be $981{\cdot}17 \times 453{\cdot}59$ dynes. If the pound is raised one foot, or 30·480cms., the work done will be $981{\cdot}17 \times 453{\cdot}59 \times 30{\cdot}480 = 13{,}565{,}100$ ergs. Since one horse-power is 550 foot pounds per second, this is equivalent to $550 \times 13{,}565{,}100$ ergs per second, which is equal to 746 081 watts.

Only a very small and quite negligible error would be introduced by taking 746 watts to 1 H.P. if the watts are strictly scientific. Engineers, however, are not provided with instruments for measuring volts, amperes, and ohms according to their absolute scientific standard. The ampere may be assumed to be an exact tenth of the absolute unit of current; but the volt of commerce, the volt which is commonly used in determining the power supplied by a central station, differs appreciably from 10^8 C.G.S. units. The direct cause of this is, of course, the determination of the standard ohm, and the closer the approximation of this standard to 10^9 C.G.S. units of resistance the more correct will it be to take 746 commercially-measured watts as being equal to 1 H P.

For instance, if the standard of resistance of 1884 be taken, which is specified as the resistance at the temperature of melting ice of a column of pure mercury 106cm. long and 1 sq. mm. cross section, it will be found that the "volt" due to the flow of exactly one ampere through this resistance will be equal to 0·998 of a true volt. Practical men will not, however, be very much troubled on this account, for the error is only 0 2 per cent. On the other hand, the ohm has received a much more exact determination since 1884; it is now generally defined as being equal to the resistance of 106·3cm of the column of mercury specified above. Practical measurements based on units derived from this evaluation will be much nearer to the truth.

The ohm, the volt, and the ampere are bound up together with the horse-power by definition, and the relation between the volt-ampere or watt and the horse-power is thus fixed at 746·081. No error in the determination of the ohm or either of the other units can affect this relation If anybody having carefully measured a horse-power electrically, and found, after making all necessary experimental corrections that it was equivalent to 748·2 watts, the explanation would be that his electrical standards were wrong, and that he had been using a Paris ohm of 160cm. instead of 106·3cm.

DR. OETTEL'S RESEARCHES ON THE ELECTRO-DEPOSITION OF COPPER.

Dr. Felix Oettel, whose contributions to the study of the conditions affecting the electro-deposition of copper in the voltameter have been noticed in these columns (see *The Electrician*, May 19th, p. 59), has recently published a further account of his investigations in the pages of the *Chemiker Zeitung*. He states that he has observed that a plate of copper suspended, without separate electrical connection, between similar plates acting as the electrodes of a depositing cell, receives on the side facing the anode a deposit of copper, and loses from that opposite the cathode a corresponding amount of metal, and hastens to claim priority in the recognition of this phenomenon, which he considers completely analogous to an inductive effect. Having thus protected his privileges as the earliest in the field of scientific research, he proceeds to act as a pioneer of technical application by suggesting the utilisation of the method in question for refining copper on a manufacturing scale.

Nothing could well exceed the accuracy of Dr. Oettel's observations or the logic of his deductions. That both are inexpugnable is amply evident from the fact that the method of arranging electrodes in a refining vat, advocated by him, has been in extensive use for several years, notably in America, where two or three well-known patented systems are particularly in favour. The description of the best of these systems, and the discussion of their respective merits, appeared in *The Electrician*, Vol. XXIX., p. 222, in an article dealing with the progress of the electrolytic refining of copper in the States. It serves as a piquant commentary on the supposed perfection of international communication and interchange of ideas and information, to find a German chemist occupying a considerable amount of space in a leading chemical newspaper with a communication, obviously written in perfect good faith, dealing with facts of quite respectable antiquity, as if they were noteworthy novelties.

Fortunately, the circumstance that Dr. Oettel is unacquainted with fairly recent progress in matters electrolytic, has led him to take an interest in the phenomena which he has examined, not usually forthcoming on behalf of the trite. Thus he has studied the relation of the quantity of copper transferred to and from the middle plate with that dissolved from the anode and deposited upon the cathode. Working with plates 86 × 131mm., not completely filling the cross section of the depositing cell, he found that the amount dissolved from the one side of the middle plate was about as much greater than that deposited on its other side as was the quantity dissolved from the anode greater than that deposited on the cathode, the difference in each case being due to the use of commercial copper, containing 98·8 per cent. Cu, for all three plates. The quantity of copper deposited on the middle plate was 87 per cent. of that appearing at the cathode, but this proportion would obviously vary according to the arrangement of the plates in the cell. A second experiment with a series of six plates, of which only those at the ends were connected directly with the battery, the plates being 90 × 95mm., and the current density 1·3 ampere per sq. decimetre, gave a deposit of copper on one side of each of the intermediate plates, ranging from 63 4 to 66 9 per cent. of the quantity thrown down on the cathode. The chief conditions influencing this ratio are:—(1) the size of the intermediate plates relative to the cross-section of the cell, or, in other words, the proportion borne by the metallic to the electrolytic conductor in a cross-section including a middle plate, and (2) the absolute size of the plates, the well-known tendency for copper to deposit more densely at the edges of the plates having obviously an effect on the total quantity of copper deposited, which augments as the length of the edges increases relative to the area of the plate, *i.e.*, as the size of the plate diminishes.

Further experiments showed that, given an identity of material for the plates and of distance between them, the drop of voltage was sensibly constant for the series, but that when an unattacked plate, *e.g.*, one of lead, was inserted in the series the drop of voltage from its anode side to the cathode side of its neighbour was necessarily increased, by reason of the fact that

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the work done was no longer the mere overcoming of the resistance of the electrolyte, but also involved the liberation of oxygen at the anode surface, results which might reasonably have been anticipated. Convinced of the necessity for a characteristic title for the arrangement of electrodes, with which Dr. Oettel has sought to identify himself, he proposes the term "kammerschaltung," *anglicé* "chamber arrangement," to distinguish it from the more ordinary methods of disposing the plates in series or parallel, to which his knowledge has been hitherto confined. We commend the innovation to the attention of electricians and chemists engaged in the electrolytic refining of copper.

REPORT OF THE ELECTRICAL STANDARDS COMMITTEE OF THE BRITISH ASSOCIATION.

The work of testing resistance coils at the Cavendish Laboratory has been continued. A table of the coils tested is given. They have all been "ohms," as defined by the resolution of the Committee given in their last report, and since adopted by the Board of Trade Committee on electrical standards in the following form :—

The resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice 14·4521 grammes in mass, of a constant cross-sectional area, and of a length of 106·3cm., may be taken as 1 ohm. The relation between the B.A. unit and the ohm is the following :—

1 B.A. unit = 0·9866 ohm.

The resolutions adopted by the Committee at Edinburgh were communicated to the Electrical Standards Committee of the Board of Trade. After consideration, the Board of Trade Committee drew up an amended report, in harmony with the Edinburgh resolutions, for presentation to the President (*see* Appendix I.).

The resolutions were accepted at Edinburgh by Dr. von Helmholtz on behalf of Germany, while in France an official committee decided last June to adhere to the propositions of the Board of Trade. Austria and Italy are connected by treaty with Germany for telegraph purposes, and in consequence adopt the same units.

The Committee have learned with pleasure from Mr. W. H. Preece, one of the English delegates to the International Congress of Electricians at Chicago, that the Congress has accepted a series of resolutions defining the fundamental units practically identical with the Edinburgh resolutions.

Thus these resolutions have now been accepted as a basis for legislation throughout the British Empire, the whole of western Europe, and the United States of America.

The Committee are also informed that the Chicago Congress have adopted the name Henry for the unit of self induction. While looking with favour on his suggestion, they think it desirable to postpone definite action until the official report of the Congress has been received.

In March last M. Mascart wrote to the Secretary asking the opinion of the Committee as to a name for the standard of resistance defined at Edinburgh. A circular letter was issued inviting members of the Committee to express their views on four names which had been suggested, viz., "International," "Normal," "Etalon," or "Ohm de 1893." After receiving replies to the circular from 12 members of the Committee, the Secretary wrote to Prof. Mascart to the effect that the number of members who expressed a preference for the name "International" was greater than the number declaring in favour of any other name, but that he thought that the Committee would accept whichever of the first three suggestions commended itself to the French Committe appointed to deal with the matter.

During the year Dr. Muirhead has re-measured his standard condenser. He now finds as the capacity of a condenser constructed 23 years ago to represent 0·1 microfarad (B.A.U.) the value 0·09998 microfarad.

Tests have been made during the year on the 1 ohm and 10-ohm standards of the Association. These are still being continued. The 100 ohm and 1,000-ohm standards have now been delivered, and the tests will be shortly proceeded with. Some experiments were made as to the amount of heating in the coils produced by the current used for testing. These are detailed in an Appendix. Further valuable information on this point is contained in Mr. Griffiths' Paper on "The Value of the Mechanical Equivalent of Heat."

The Committee think it desirable that they should be in a position to complete the set of resistance standards of the Association, and recommend, therefore, that they be reappointed, with a grant of £25, that Prof. G. Carey Foster be chairman, and Mr. R. T. Glazebrook secretary.

THE DEVELOPMENT OF GRAPHIC METHODS IN MECHANICAL SCIENCE.*

Graphical Solution of Problems.

In the absence of Mr. Preece (Chairman of this Committee) and of Lord Kelvin and Sir Benjamin Baker, it devolves upon me, as secretary of the Committee on Graphical Methods, to present a brief extract of the report. The first and preliminary report on this subject was presented in 1889. The second report was presented last year, and was divided into four parts :—

(1.) General geometrical considerations.
(2.) The representation of results graphically.
(3.) Graphical solution of problems.
(4.) A tabulated list of reference to graphic methods to be found in the scientific literature of this country.

Only a brief treatment of the third division was possible. This included quotations from various authors concerning the development of the subject, and a summary of graphical problems, though a more complete account was given of these branches, viz., slide rules and mechanical integrators. The present Committee was appointed to prepare a third report on the subject, dealing as completely as possible with the unfinished portion of the second report, viz., "The Solution of Problems." The study of the second report, particularly of the classified list of references, conclusively shows that graphical solutions have, in this country at any rate, almost entirely proceeded on two lines.

(1.) Interpolation of plotted results.
(2.) Use of reciprocal diagrams in structures.

The former, although arriving at results which would be difficult, if not impossible, to obtain in any other way, is itself a remarkably simple operation, the chief part of the work really consisting in the preparation of the diagrams in which the interpolation is made. This matter was treated very fully in the second report, both for plotted curves and instrumental methods for obtaining them. The latter, namely, the use of reciprocal diagrams, was largely employed, chiefly because of their simplicity. It forms, however, only one branch of what is now known as graphical statics, which in turn only include one class, although the most important class of graphical problems. There has been such a large amount of research in connection with the solution of problems that it is impossible in the compass of a report to do more than to give a summary of this problem. What, however, is extremely necessary at the present time is a general treatment of the methods upon which the solution of all problems is founded. It is also important that some definite recommendation should be made concerning the teaching of graphical methods, the practice in which differs extremely in various parts of the world. The following is, therefore, the scheme adopted in the report :—

Division I.—Graphical outlines in general.

Division II.—Summary of problems which have graphical solutions.

Division III.—The teaching of graphical methods.

The Secretary of the Committee then proceeded to give a short account of the Report under the three above headings :—

(1.) Division I. chiefly consists of a discussion of the operations with segments or lines, which are the only means of graphical calculation, definite portions of lines representing numerical quantities, and only such geometrical operations (being of interest) as enable definite numerical results to be obtained. The first subject discussed is the operations with segments which have been classified in books under the title of "Operation with Lines," or as "Graphic Arithmetic," and various suggestions are made as to the views

* Third report of the British Association Committee, consisting of Mr. W. H. Preece, Lord Kelvin, Sir Benjamin Baker, and Prof. H. S. Hele-Shaw (secretary).

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which should be held on what may be called simple graphical operations. The following sections are then treated :—(*a*) Representation of areas and volumes by means of segments, (*b*) the additions of segments, (*c*) the combinations of segments, (*d*) the multiplication of segments, (*e*) the summation of the funicular polygon, (*f*) centroids and moments of inertia (derived diagrams), ( ) central ellipse and kern, (*h*) the sum of the products of non-parallel segments, (*i*) properties of reciprocity, (*j*) the null or focal system.

(2.) Division II. has the following heading :—(*a*) Force in its application to bodies considered as being rigid, (*b*) force in its application to bodies considered as being elastic, (*c*) machines, (*d*) hydro-mechanics and naval architecture, (*e*) miscellaneous.

Under the heading (*a*) are classified the general treatment of external and internal forces, framework, arches, retaining walls and tunnels, masonry piers ; (*b*) includes the simple beam, elastic line and curve of deflection, continuous girders, elastic arch.

(3.) Division III. the examination into the treatises and systems of dealing with graphical methods which has been necessary in the preparation of this report, has revealed the great divergence in the nature of the teaching of graphic methods in engineering colleges and schools throughout the world. The Committee, therefore, felt that some practical results might ensue if information was collected from various sources as to the nature of the teaching in different countries, such as the number of hours devoted to the subject and the kind of teaching given, and also felt that it was possible certain specific recommendations on the subject might be made.

The above examination of the different systems and courses of instruction both in Europe and America reveal the fact that the solution of problems graphically received a certain amount of attention in nearly every engineering course of instruction In England such instruction is given as a rule, in most colleges incidentally, when the subjects of statics, machines, or hydraulics are being dealt with, although recently in some cases special training in graphical methods is being introduced as a part of the course of engineering instruction, in several cases being given as a branch of descriptive geometry. Thus in the Science and Art department, both under the heads of descriptive geometry and also machine drawing, a knowledge is expected of some of the elements of the subject. On the continent of Europe, however, for many years, not only have special courses of lectures been devoted to the teaching of graphic statics as a separate branch of the subject, but there have been a large number of schools in which there are special professors of graphical statics. The reason for this difference is to be found, not altogether, as it is often supposed, in a want of appreciation on the part of English engineers or professors of graphical statics -for it was in England that the germ of such methods was first developed by Rankine, Clerk Maxwell, Fleeming Jenkin, and others -but because the system of appointing professors in the special polytechnics devoted to the allied sciences is there in vogue rather than in England, where one or two chairs of engineering are added to other chairs of the university or university college.

Now, it is instructive to note the general method of instruction indicated in the syllabuses of engineering schools, and which are even more clearly shown in the various text-books on the subject. From these it is clear that the general methods consist of giving certain rules, which may be called general graphic methods, and which apply to addition, multiplication, powers, and extraction of roots, which may be regarded as forming the introductory portion. This is followed by what may regarded as an introduction to statics, in which special stress is laid on geometrical constructions, and the solution of many problems are given which would otherwise be worked out by analysis.

The report then proceeds to discuss the nature of this teaching, and concludes as follows :—It is clear that courses of instruction might be given under the head of Graphical Methods, which might be taught in the same way as descriptive geometry, and which ought, indeed, to be worked in conjunction with that subject. This subject should deal with the construction of such geometrical figures as are important for graphical application. It should also deal with the plotting of results and the general properties of plane curves, as far as the student is able to numerically effect measurements with it, which he can check by calculation. A student should be expected to do his work with great accuracy, and to regard the results he obtains as accurate enough to be useful in practical work, although such examples need not at the time be applied to any practical engineering problems. Thus, for instance, the propositions of projective geometry, so far as the null or focal system is concerned, and the projective properties of bodies, and of the pole and antipolar, might be taught ; but a systematic treatment of the subject of projective geometry is not necessary for engineers. With regard to projective geometry, it may be said that, unless it is desired to study the higher branches of the subject, there is no necessity whatever of a treatment such as Culmann has given in his chapters on the "projective relations between the polygon of forces and the funicular polygon" and the "relation of a system of forces with the focal system, and with curves of the third degree," or with the central axis of a system of forces, or colinear and reciprocal relations of the funicular or force polygon.

There appears to be no reason, therefore, why an elementary course of a general nature, specially arranged so as to include all that an ordinary engineering student requires to know of graphical methods, should not be introduced as a regular subject in engineering schools, and the following arguments may be brought forward in support of this view :—

(1) Although the time-tables of an engineering department are already full, yet it will be found that a course such as that suggested really includes much of what is taught at present in a desultory way, and such a course would obviate some of the teaching given under the heading of "descriptive geometry," so that during one or two terms of a year it might be taken during the same hours as already devoted to descriptive geometry, with possibly one lecture a week, for one term, in the place of the actual lectures in the applied engineering, into which at present graphic methods are often obliged to be introduced for the want of proper preliminary training in the subject by a student. Moreover, the time now devoted in the engineering laboratory for the plotting of curves might be much better occupied in the drawing hall itself in connection with the practice of the plotting and interpolation of curves as a part of the subject of graphic methods, the data obtained from the engineering laboratory affording useful information.

(2) The time spent in such graphical work would be an excellent discipline in accurate drawing for a student, who is often inclined to regard a sketch roughly representing an idea as sufficient for practical purposes. A student should learn for himself that nothing is so easily deceived as the eye. It is quite true, as Prof. Culmann says in the preface of his work, that the constructing engineer will give preference to geometrical solutions wherever an accuracy of results up to three decimals (one-thousandth), which can perfectly well be obtained, is sufficient, for his drawing instruments are always at hand, and drawing is his habitual expression of thought. But such accuracy in drawing is by no means naturally or intuitively acquired, and the student requires training in a course of graphical methods before he would appreciate their value. Moreover, such practice in actually performing the operations, and becoming familiar with the solution, is absolutely necessary, if it is to be expected that a student will really use these problems afterwards in his practical work, as such modifications become extremely puzzling owing to the want of a thorough acquaintance with the methods.

(3) It is not only necessary that a student should be familiar with accurate drawing, but also that he should be familiar with graphical constructions as a means of solving problems. The plan ordinarily adopted in the teaching of statics in conjunction with graphical methods themselves seems expecting too much for the capacity of an ordinary student and the difficulty of getting a class of even intelligent students to correctly solve problems out of the beaten track to the difficulty involved in combining these two things. In the use of ordinary geometry or analytical methods there are separate classes for algebra, analytical geometry, trigonometry, &c., and yet the ideas involved in them are no more difficult than those included in graphical constructions and methods. Graphical methods certainly, therefore, have the same claim to be considered as a separate branch of study.

The following proposition, supported by these arguments, is therefore brought forward :—"That in all engineering schools a separate course in graphical methods of construction may with advantage be introduced which shall deal with such problems as have a practical bearing on mechanical science, and which do not involve applications of any concrete subjects, such as statics and dynamics, *but which may familiarise the student, by means of examples accurately worked out by himself, with methods which he will be afterwards able to apply.*"

It is satisfactory to know that this proposition, which was brought forward at the recent International Congress at Chicago by Prof. Hele Shaw, received the general approval of a very representative body of engineers and professors.

The report concludes with a tabulated statement of the present state of the teaching of graphic methods in Europe and America.

Standard Time in Italy.—According to the provisions of a recent legislative enactment, the railway service of the entire kingdom of Italy will be regulated, on and after November 1st next, by the mean solar time of the 15th meridian east of Greenwich, and the hours will be reckoned from midnight to midnight. This amounts to the adoption of the so-called middle European time, which is one hour in advance of Greenwich, and eleven minutes in advance of the mean solar time of Rome. It is expected that the other public services, and the communities in general, will soon adopt the same system.

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Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.

Editorial, Publishing, and Printing Offices :

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.

Telephone No. 2714. Telegrams : "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co.*"

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SUPPLY AND DEMAND.

The mania among parents and guardians for "putting" their sons and wards "into electric light" has not yet received the natural check which can alone be given by the law of supply and demand. Soon after a demand for electrical engineers had been felt, technical colleges and other institutions sprang up to furnish the supply. These institutions, not contenting themselves with teaching scientific principles, are encouraged by the popular craze for technical education to impart a smattering of trades and handicrafts; and so far has this gone, that some of them boast of private central stations, in which the student is supposed to get an acquaintance with real central-station work. The pendulum must soon begin to swing the other way, when the supply exceeds, in actual quantity, or in apparent quality, the demand, which, though really tending to steadily increase, is practically diminished by over-production. There is generally a time-lag between the application of the law of supply and demand and its result; demand, as a rule, preceding the supply. Especially in the case of the failure of demand and the diminution of supply, this lag brings with it much disappointment. On the other hand, to take at the flood the tide in the affairs of men, and to follow it when it leads on to fortune, is an obvious proceeding. Sometimes a mere fool can ride in to success on the crest of this wave, but when the surge is strong and the bottom is shoaling none but a strong man can fight with the breakers. The scientific plan, and the one adopted instinctively by those who enjoy a business instinct, is to take the wave at about a quarter of a period before the apex, thus taking advantage of the converse time-lag between the rise of demand and the consequent development of supply. Unhappy, indeed, is he who is out of phase with

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the day, and struggles in the trough of the wave, or, in mathematical language, under the curse of a negative sign.

One of the most recent demands has been that of municipal authorities for consulting engineers. A few men have been having a merry time, and now others, with or without qualifications, are rushing in. The situation is most unfortunate for the municipal authorities, for they confessedly know nothing about electric supply, and too often nothing about their adviser. There is room for many kinds of malpractice, and even fraud, between the extreme cases of absolute incompetence and of concealed connection with contractors, or of actual contracting under another name. Happily the demand for this branch of consulting engineering must speedily decline, because the municipal engineers of the next generation will be expected to add general knowledge of the supply and distribution of electrical energy to their qualifications, and the expensive services of gentlemen who are believed to keep reports in stock, only filling in names and figures for each case, will be dispensed with.

Ten years ago, when the possibilities of electrical engineering as a new branch of the profession were felt, and when its limitations and development could not be foreseen, there were many who, remembering the fortunes made during the railway mania, and the imposing reputations made by sheer luck at that time, and kept up by mere courtesy to-day, thought that electric lighting and the other vague possibilities of electrical developments might lead to such another loud demand. Through various causes, attributed by some to the Electric Lighting Act of 1882, by others to reckless company promotion, and by a small minority to the undeveloped condition of electrical engineering, the demand was but small and the growth of the industry was gradual. Another limitation which might indeed have been foreseen was the sub-division of the profession of electrical engineering into heavy engineering, such as dynamo building, lighter manufactures, instruments and switch work, and the gradual passing of wiring and fittings into the hands of enterprising gas-fitters. While everyone must regret that wiring should be undertaken by decorators and ironmongers who, knowing nothing of the work, rely on the services of a foreman and are kept from doing serious mischief only by the rules of supply companies and insurance offices, this is not due so much to disinclination of busy dynamo makers to bother about wiring and fitting, as to the up-springing of firms who confine themselves to this work. Scores of young men start in twos and threes as general electrical contractors, but practically do nothing but wiring. "Messrs. Dyck, Thomb and Harrie," runs the familiar paragraph, "beg to announce that they have severed their connection with the Brush Company, and have gone into business on their own account, and a £5 note, their offices being in Victoria-street, S.W." It was hardly for this work that parents "put" their sons "into electric light." The very rawness of such firms, as well as the huge bills of extras, have given work for consulting engineers, but this seems to be a temporary phenomenon. A fee to really remunerate the work of a consulting engineer in specifying not only for the quality and mode of wiring, but for the positions of lamps and switches, testing the insulation, and fighting for his client over the extras, must add very materially to the cost of introducing electric light into a house. This branch may perhaps pass into the hands of architects, and no one will indulge in the luxury of a consulting engineer for such work unless he means to hand over himself and his house to the mercies of an architect.

There will, of course, be an "up" for every "down," and it is in no pessimistic spirit that we have endeavoured to forecast a few "downs." Electricity, though no longer in its infancy, is hardly yet in its maturity. A contemporary recently recorded the fact that the alternate-current motor problem had not been solved for three weeks, possibly because inventors, aware of the principle of lag between supply and demand, are waiting until the demand wave definitely rises above zero. The problem of cable telephony and high-speed cable working has been deliberately brought forward to stimulate a demand. Such economic self-induction is well recognised, and the clever salesman is he who persuades a customer to buy something that he does not want. But the abnormal advance of supply in front of demand is associated almost entirely with luxuries, and no one can deny that ocean telephony, even if perfectly feasible and requiring no impracticably expensive cable, would be a mere luxury. But the element of chance comes in, since the luxury must "catch on." This the phonograph has failed to do, and, after many years of obscurity, is appearing among street shows, and finds a pitch between the fat woman and the steam merry-go-round at fairs. A not unlike case occurs when the supply exceeds the demand to a ridiculous degree, as in the invention of arc lamps. Hundreds have been invented at an immense expenditure of ingenuity and money, and about three are really successful, and none perfect. Artificial restrictions have, according to one view, impeded the development of the glow lamp in this country, and, according to others, supported, indeed, by what we hear of most foreign lamps, the immunity enjoyed by monopoly has allowed opportunity for unusual care and skill in the manufacture. The price of the more usual sizes of glow lamps was reduced from three-and-ninepence to one-and-ninepence yesterday, and although this voluntary concession will no doubt relieve the shock, with the expiry of the patent a sudden discharge of accumulated supply may be expected. Oscillations or unstable conditions may be expected to last a twelvemonth or so, and will be watched with interest. A ninepenny lamp is, after all, a trifling matter, equivalent to five per cent. or so on the meter bill; but one more example may be given, where the cost runs to millions of pounds. In this a strong demand exists, and becomes more and more imperative; we allude to electric traction, either on tramways or underground. Hastily-conceived schemes for importing American plant, ready designed, ready made, and warranted to do everything but run at fivepence a car mile, is not the way to develop electric traction. The growth of the demand in advance of the supply is a healthy and really stable condition, and we hope that the curve of demand in electrical undertakings, though necessarily subject to fluctuations, may never fall below its axis.

REVIEWS.

Numerical Examples in Practical Mechanics and Machine Design. By R. G. Blaine. (London: Cassell and Co. 1893.)

One of the most efficient methods of impressing a principle or illustrating a practice, in science, consists in working out numerical examples or problems. As an aid to the lectures, problems serve the useful purpose of thoroughly grounding the student in the exact meaning and relationship of physical quantities and of the terms by which they are expressed; thus etching into his mind the principles, the first general statement of which he receives in the lecture room. As an adjunct to the workshop, the working of problems in leisure hours tends towards uniting the daily empirical practice with theory, and serves to correct the looseness of ideas which mere workshop practice is liable to breed. Problems lie as a connecting link between theory and actual practice,

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and neither the one nor the other can be fully grasped in all its essential bearings without a certain amount of exercise of this kind. But there are problems and problems. There is the highly differentiated impracticable problem which, with much chagrin, the student meets in certain examination halls, and there is the problem which is designed not to trick, but to instruct. It is to the latter, of course, that our commendations solely relate; but even here we must discriminate. Those who have had considerable experience in conducting problem classes will agree with us that there is a certain indefinable and totally unaccountable catchiness about some problems, which is not to be found with others that, to all external appearances, are of equal value. Some problems go straight to the student's difficulty and unearth it at once; they seem to catch on directly. Others, while dealing with the same facts, appear to be capable of teaching little or nothing. In general, it would appear better to construct a problem so that the mere arithmetical part of it will work out easily, rather than to so select the magnitudes that the student's mind is bewildered in a maze of awkward roots and inconvenient decimal places. A careful instructor will be on the watch to sift out of his problem-book all those examples which do not stand the fire of active service; so that, at the end of several terms, he will possess a refined and tried collection, which will be of the greatest value in driving physical truths home to the student-mind. It is just such a well-tried assortment of problems which we find before us from the pen of Mr. R. G. Blaine. These have all been selected from the best of the problems used in the classes at the Finsbury Technical College. We can strongly recommend them to students, apprentices, and all sorts and conditions of engineers; for they are well arranged, well illustrated, cheap, and handy, and it will be likely there is not a man among us but who will learn something useful from a perusal and practice of them.

It is very rarely that such a book as this is not prepared "to meet the requirements of" certain examinations. The present work, for which Prof. Perry has written an introduction, is quite free from this evil.

THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 529.)

A little calculation about the Geissler form of pump, with, say, the capacity of the pump bulb equal to that of the lamps being pumped, shows that it should not take very many strokes in order to reduce the amount of air in the lamps to something very close indeed to zero. In practice, however, it takes very considerably longer than the calculation would lead one to expect. The reason of this is twofold. Firstly, the carbon filaments of the lamps occlude gas, which takes time to come out; and, secondly, the air has a way of sticking to the glass, both of the pumps and the lamps. The occluded gases are removed by lighting up the lamps, when the exhaustion has proceeded far enough to make it safe to do so. The current should not be turned on until the vacuum in the lamps appears to be as good as can be obtained. The filaments are brought to a dull red heat only, at first; and gradually, as the gas driven out is pumped away, they are made brighter and brighter until eventually they are brought up to a state of incandescence, equal, at least, to that at which they will be run as finished lamps. When the current is first turned on, it will at once be seen that gas is driven from the filaments by the pump again taking out air. After the full brightness has been reached, the pumping must be continued until the vacuum is again as perfect as possible.

With regard to the gases which come from the filament when it is thus heated by the current, those which come off at the temperature of red heat, and below, are, no doubt, rightly termed "occluded"; that is to say, they have been absorbed by the filament since carbonisation. Those, however, which make their appearance when the filaments are bright are more probably products of the more complete carbonisation of the filaments by the high temperature to which they are subjected by the current.

The other action, which prolongs the time required to perfect the vacuum beyond the theoretical amount, that of the air sticking to the glass of the pump and the lamps, is more difficult to deal with. This air, which appears to adhere as a film to the glass, will come off gradually, but the process is a very slow one. In order to assist it the lamps are heated during the pumping. Unfortunately it is not such an easy matter to heat the pumps, and it is seldom attempted, except in the laboratory. In Fig. 32 on page 528 of last week's *Electrician* a device for heating the lamps is shown. A metal cover is lowered over the lamps, and a Bunsen gas flame is applied below. The lamps can thus be heated to any desired extent up to the softening points of the glass.

In some factories the lamps are attached to the pumps the other way up. This, however, is not so good, as the lamps cannot then be so well heated, as there must of necessity be a hole in the top of the cover allowing of a circulation of cold air.

When the lamps are heated, the air is driven off the glass and is pumped out. Fortunately for the lamp-maker, the removal of the air film from the pump itself, and from the tube leading to the lamps, is of no very great consequence, for the reason that it takes such a long time to come off. It is not necessary to make elaborate arrangements for heating the pumps. If a pump, being perfectly air-tight and in good order, be worked until no more air is taken out, and it be then left to itself for 24 hours, and after that interval be started again, it will be found to again take out air. This air having come off the surface of the glass. It takes some hours for an appreciable quantity of air to accumulate in this way. Although, then, when the pump ceases to take out any more air, and there is still a film of air adhering to the glass, there may be, nevertheless, an exceedingly good vacuum within the pump and the tubes and the lamps. The lamps themselves, having been heated, do not contain an air film, while the air film on the glass of the pump and the tubes takes a long while getting into the vacuous space. The lamps can, therefore, be sealed off before the air film has had time to come off the glass of the pump and spoil the vacuum. The vacuum in the lamps may, therefore, be just as good as though the pumping had been going on for some days, gradually getting rid of the air film in the pump.

When the lamps are sealed off, air is let into the pump before another lot of lamps is sealed on. On account of this the air film in the pump is renewed with each batch of lamps, and is never got rid of. At the British Association meeting in 1890, Mr. Swinburne described a method for sealing on fresh lamps without letting the full atmospheric pressure of air into the pump. Fig. 34 shows the arrangement. The tube A leads to the lamps, and the tube G to the pump. There is a vessel of mercury in connection with the bottom of the tube D, so that when there is a vacuum in the pump and the lamps there is a column of mercury in D reaching to the point C. When a batch of lamps is sealed off, and another lot is to be sealed on, the mercury reservoir below D is lifted sufficiently to cause the mercury in D to rise and fill the bulb B, and, to an equal height, the tube E. A cock in the lower part of D is then turned, thereby cutting off communication with the movable mercury reservoir. Air is then let into the apparatus at the point where the lamps are to be sealed on. The result is that the air entering through A drives the mercury from B up the tube E F, where it will stand at the barometrical height above the level in B. The lamps are now sealed on, and are exhausted through a tube connected to A by a mechanical pump. The mercury column in E F therefore descends until it is nearly level with that in B. The connection between A and the mechanical pump is then sealed up. The cock in D is again opened, and the mercury reservoir is lowered. The mercury, therefore, runs out of B and E to about its former height, C, in the tube D.

* Abstract from a book to be published shortly by *The Electrician* Printing and Publishing Company (Limited). All rights of republication reserved.

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passa ge is then open between the new lot of lamps and pump which is then set going. In this way the greatest sure of air at any time allowed within the pump can be down to that equal to about half-an-inch of mercury. Such ntrivance would, however, be of little practical use in con tion with most forms of pump, because there is another nnel by which the air-film in the pump is continually main- ted.

There is, however, a far more serious trouble than that of air film to be guarded against in working with mercury ops. It is that of moisture. Any moisture in the pump l make a good vacuum an impossibility. It will be impos- e to obtain an exhaustion of less than the tension of the ter vapour, which is so great that the vacuum obtainable is nearly good enough for a lamp. At the ordinary tempera- e of the air the pressure is equal to that of about half an h of mercury. In order, therefore, to keep the pump dry, re is always a "drying tube," containing some substance ving a great affinity for water, connected to the pump. This e is usually inserted between the lamps and the pump, so to prevent any moisture from the lamps from passing into pump. Calcium chloride, or strong sulphuric acid, have en employed as the drying agent, but the only really effec- e drier is phosphoric anhydride. A tube, or tubes, of is substance (a white powder) are connected, so that

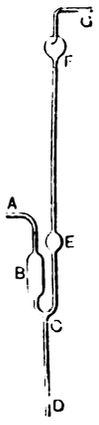

FIG. 34.

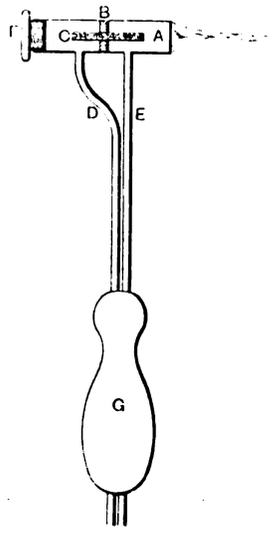

FIG. 35.

he air passing out of the lamps must pass over it. The mps should be as dry as possible before they are sealed o the pump, or the drying tubes will have to be very requently renewed. Between the drying tube and the pump here should be a small bulb containing glass wool, to prevent ny of the powder from being blown round into the pump. The amps should be joined to the pump by fusion. Rubber and ther joints are not to be relied on. In sealing a lamp on to he pump a hand blow-pipe must be used, and on no account nust the lamps be blown into in order to blow out the joint. When glass tubing is softened by heat it always caves inwards, and it is usual in glass-blowing to blow into the tube in order o prevent the passage from being closed up. After a little practice it is quite easy to seal on lamps without having to blow into them. If, however, it is desired that the joints be blown out, the air contained in the pumps and the lamps themselves can be made to do the work. When the lamps are sufficiently exhausted they are sealed off by melting the narrow part of the stem close to the bulb, by means of the pointed blow-pipe flame. The stem of each lamp sealed off is there- fore left on the pump. In sealing on fresh lamps only one of these stems is cut off at a time, so that as soon as the new lamp is melted on there is no outlet for the air in the pump and the lamps. The heat of the joint being made, warms the air within the apparatus, and the air consequently exerts a pressure within, and blows the softened glass at the joint outwards. With a little practice this can be done with certainty to the required extent each time. If several lamps are exhausted at the same time on each pump, there is a good deal of time lost in sealing on each one separately in this way. It is, there- fore, better to cut off the whole of the "fork," to which the lamps are attached, and seal on a fresh one to which the lamps have already been attached. There is then only one joint to be made on each pump, instead of one for each lamp.

In order to do the sealing on easily, it is necessary to have a small and light blow-pipe. Fig. 35 shows one designed by the author for the purpose. It is so small that it can be used in places where there is very little room to work. A is the brass barrel about 2in. long, divided by a partition, B, in the centre. A tube, C, is screwed into B, and forms the air nozzle. D is the air-blast pipe, and E is the gas pipe. The air-jet tube, C, can be adjusted by screwing it in or out with a screw- driver, by taking off the cap F. The pipes D and E pass through a wooden handle, G, and are connected to the air and gas supply. The rubber air and gas tubes are entirely out of the way, and do not impede the manipulation of the blow- pipe as they do when attached to the barrel in the usual way.

Unfortunately, moisture can, and often does, get into the pumps, and seriously interferes with their working in spite of the drying tubes. It gets in along with the air used for rais- ing the mercury. It is naturally most troublesome in damp weather. It gets worked in in exactly the same manner as the air film already described. The trouble is greatest in pumps where the mercury is raised by compressed air. The author has tried passing the air over calcium chloride before it enters the pump reservoir. In damp weather a lot of moisture was absorbed in this way, but it did not entirely prevent the entrance of moisture into the pump. In the case of hand or other pumps where the mercury reservoir is itself lifted, air and moisture might be prevented from entering by having the top of the reservoir entirely closed. The reservoir would then require raising 30in. higher than it otherwise would, owing to the absence of air-pressure on the mercury.

(To be continued.)

LIST OF THE ELECTRICAL PAPERS READ AT THE BRITISH ASSOCIATION.

The following is a complete list of the electrical Papers read and reports presented at the Nottingham Meeting of the British Association :—

SECTION A.

LORD KELVIN, P.R.S.—"On the Piezo-Electric Property of Quartz."

LORD KELVIN, P.R.S.—"On a Piezo-Electric Pile."

PROF. G. F. FITZGERALD, F.R.S.—"Equations for Calculating the Effect of a Long Tube as a Magnetic Screen."

PROF. G. F. FITZGERALD, F.R.S.—"Equations for Calculating the Effect of a Hertzian Oscillation on Points in its Neighbourhood."

PROF. G. F. FITZGERALD.—"On the Period of Vibration of Disturbances of Electrification of the Earth."

PROF. OLIVER LODGE, F.R.S.—"Supplementary Note on the Ether."

PROF. OLIVER LODGE, F.R.S., and MR. F. H. NALDER.—"On a Physiological Galvanometer."

PROF. OLIVER LODGE, F.R.S.—"On the Connection between the Ether and Matter."

PROF. A. W. RÜCKER, F.R.S.—"Note on the Magnetic Shielding of Two Concentric Spherical Shells."

PROF. J. VIRIAMU JONES.—"On Standards of Low Electrical Resistance."

F. H. NALDER.—"Apparatus for comparing nearly equal Resistances."

E. H. BARTON.—"On Electrical Interference Phenomena Somewhat Analogous to Newton's Rings, but Exhibited by Waves in Wires."

G. U. YULE.—"On the Passage of Electric Waves through Layers of Electrolyte."

G. H. BRYAN.—"Electromagnetic Trails of Images in Plane, Spherical, and Cylindrical Current Sheets."

A. B. BASSET, F.R.S.—"On the Publication of Scientific Papers."

PROF. J. J. THOMSON, F.R.S.—"A New Form of Air-Pump."

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J. LARMOR, F.R.S.—"Magnetic Action on Light."
Report on the Present State of our Knowledge of Electrolysis and Electro-Chemistry.
Report of the Committee on a National Physical Labo tory.
Report of the Committee on Electro-Optics.
Report of the Comm'ttee for Comparing and Reducing Magnetic Observations.
Report of the Committee in connection with the Magnetic Work of the Falmouth Observatory.
Report of the Electrical Standards Committee.

SECTION B.

Dr. M. MESLANS.—"Demonstration of the Preparation and Properties of Fluorine by Moissan's Method."
Dr. C. A. KOHN.—"The Application of Electrolysis to Qualitative Analysis."
Report of the Committee on the Silent Discharge of Electricity in Oxygen and other Gases.

SECTION G.

W. W. BEAUMONT.—"Automatic Balance of Reciprocating Mechanism."
W. W. BEAUMONT.—"New Form of Variable Power Gear for Electric Motors."
GISBERT KAPP.—"Relative Cost of Conductors with Different Systems of Electric Power Transmission."
A. T. SNELL.—"Utilisation of Water-Power by Electricity."
W. B. SAYERS.—"Self-exciting Armatures and Compensators for Loss of Pressure."
E. PAYNE.—"Mechanical System of Electric Conductors."
Report of the Committee on Graphic Methods.

THE BRITISH ASSOCIATION AT NOTTINGHAM.

Thursday, September 14th.

The proceedings of Section A were opened in Nottingham to-day by an exceedingly interesting Address by Mr. R. T. Glazebrook, on the ether theory of light in relation to the difficulties which led to its earlier acceptation by Newton. The attendance varied between 100 and 120, according to the phase of the lecture, and when the reading of reports began it fell to less than half that number. At the conclusion of the President's Address a Nemo arose from out the crowd, and requested to be allowed the voice of oratory, which being vouchsafed, he proceeded to a demolition of the ether theory, a proceeding which, however, was nipped in the bud by the outcries of the audience and the veto of the President. Excitement, momentarily raised to a higher than normal pitch, fell to zero before a series of reports, most of which reported nothing save that the Committees wished to be re-appointed and, in many cases, to have a further grant of money. Report stage was thus quickly, if uninterestingly, passed, and the proceedings hurried on to the most valuable and interesting part of the morning's programme, namely, the Paper by Prof. G. F. Fitzgerald on "The Period of Vibration of Disturbances of Electrification of the Earth." Considering the earth firstly as an isolated charged spherical conductor, the period of oscillation of any electromagnetic disturbance caused by a perturbation of the electric charge was calculated. Secondly, considering the fact that there is entirely surrounding the earth a spherical shell of conducting highly rarefied atmosphere, the capacity should really be that of two concentric spheres and much greater than one isolated sphere; a result which, in itself, would considerably alter the period of oscillation. But the proximity of the outside conductor would also alter the self-induction of the system, bringing two inductive current elements near together at each electric disturbance on either sphere. The combined result of the increased capacity and of the decreased self-induction of the system was found to result in a very inappreciable change of the periodic time of the electromagnetic oscillations. A distribution of 80 C.G.S units of charge per square centimetre would be capable of causing 10 per cent. variation of the value of the earth's magnetic force, equal to a magnetic storm of unattained power; but the smaller variation of one-hundredth of H might arise from 8 C.G.S. units per sq. cm. in actual fact. It would be interesting to arrange a large number of needles of various periodicities, so as to get a response to any natural electromagnetic oscillations which might occur, but Prof. Fitzgerald has not yet succeeded in arriving at any definite practical result. Incidentally Prof. Fitzgerald answered the question in the Presidential Address: What is an electric charge? Outside the charged body, he said, there is a stress in the ether; inside the charged body there is a stress in the matter; and the measure of the quantity of the electric charge is simply the measure of the latter stress, the charge being located at the place where one stress ends and the other begins. Prof. Lodge, in the interesting discussion which ensued, observed that he considered such researches should be conducted in a magnetic observatory and not in a physical laboratory, as in the latter place there is a liability to serious magnetic disturbances due to local causes. He also remarked that the supposition of an envelope of conducting material concentric with an atom, or the conception of an atom as electrically equivalent to two small concentric spherical conductors separated by dielectric ether, might be found to explain the discrepancy between the actual period of light vibration of the atom of a heated gas and the theoretical period which that atom should have, assuming it to be equivalent to a simple isolated sphere. In replying to this last point, Prof. Fitzgerald remarked that such an atom would be incapable of producing external radiations on account of any harmonic disturbance of its ionic charge, and that all its actions would lie internally with respect to the outer envelope. The remaining Papers were of an astronomical and optical nature and interest. In section G there were no electrical Papers.

Friday, September 15th.

This was a busy day in both Sections A and G. In Section A the Papers were devoted to electrical and optical theory and to electrolysis. In Section G the Papers were chiefly of interest from a central-station point of view, dealing with mechanical engineering questions. In Section A comments were made on the report on "The Present State of our Knowledge of Electrolysis and Electro-Chemistry." This report states that a comparison of the numerical results of electrolytic observations is rendered difficult from the fact that the data are scattered in various periodicals, and expressed by different observers in units that are not comparable without considerable labour. An exhaustive table, in which are included all the observations, as far as they are known for the metallic salts and mineral acids, has been compiled by Mr. T. C. Fitzpatrick. The data included refer to the strength and specific gravity of solutions, with the corresponding conductivities, migration constants, and fluidities. The chief Paper of the day was read by Dr. Lodge, on the "Connection between Ether and Matter." This Paper, which gave the results of a number of experiments made by Dr. Lodge to discover whether there is any direct mechanical connection between matter and the ether around it, gave rise to a lengthy and interesting discussion. Incidentally, Dr. Lodge made some incisive and caustic remarks on the evils of being too explicit. "The beauty of mathematics," said he, with delightful naivity, "is that it is so vague!" Up to a certain point an equation is perfectly exact, but beyond that point it is capable of varying interpretation. Leaders of scientific thought are often pressed to give some mechanical meaning to their formulæ-theories; and the explanations are twisted by their disciples into distorted ideas, and are pressed altogether beyond the intended limits. A leader tells his disciples—"if he is so fortunate as to have any disciples"—that the ether represented by a certain equation behaves *like an elastic solid*. Forthwith it is published by the said disciples that he said the ether *is* an elastic solid, and so on.

The apparatus designed by Dr. Lodge consisted of two flat circular discs of tough steel, one yard in diameter, rigidly fixed in two horizontal planes to a vertical spindle, at a distance of 1in. apart. This apparatus was set in very rapid rotation—in most instances the speed was as high as 3,000 revolutions per minute—and while thus in motion the gap between the discs was traversed circumferentially by two equal rays of light, one ray passing round in the direction of motion of the discs, the other in the reversed direction. By an arrangement of plane mirrors it was possible to make each of the two rays of light

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pass five or six times round the circumference of the discs in the air gap between them; but usually only three rotations of the light was arranged. The interference bands formed by the superposition of the two rays were directed upon a screen, and the effect to be observed was whether any displacement of these bands took place when the discs were first at rest and then set in rapid motion; and further, whether a reversal of the motion of the discs would reverse the displacement of the interference bands. The errors to be eliminated might arise from the intense air pressure on the mirrors, set up by the whirling motion, by the heating of the air and discs, and by the actual displacement of the ether due to the motion set up in the air in the gap. The first was eliminated by the use of glass windows in a screen of metal completely enveloping the rotating discs. The last was corrected by an application of Fresnel's formula—

$$1 - \frac{1}{\mu^2},$$

which gives the proportion of the ether set in motion by the moving air, and which in this case came out to $\frac{1}{200}$th of the speed of the discs. When every effect had been traced to its probable source, the resulting deduction might be drawn that there is no mechanical connection between the ether and the matter which it may surround; that, in fact, the motion of gross matter does not set the environing ether in motion with it. Stress-energy belongs to the ether; inertia-energy belongs to matter; and no mechanical interchange of energies takes place. Every action may be considered to commence and to terminate on lumps of matter—ordinary gross matter; and there is no line of stress leaving any portion of matter and sticking out into the ether without coupling itself to some other portion of matter. In other words, Newton's third law of motion relates to two portions of matter if it relates to one. Such is the gist of the conclusion arrived at by Prof. Lodge.

In the discussion which followed this Paper Prof. Hicks remarked that he considered the negative results quite inconclusive, because there was no evidence to show that the dics would not require a very much longer time than had been given in order to stir up the ether. The experiment had been conducted after several hours' motion of the discs. What was there to prove that the ether might not require hundreds of years? In reply, Dr. Lodge said that if the question of time must enter into consideration, there was no reason to suppose that three hours was better than three minutes, and that if the effect was not practically instantaneous it might take many thousands of years. All our experience of the ether would lead up to suppose it would readily take up such disturbances. He had observed the interference bands close up to the image of the discs, and had detected no trace of displacement. Prof. Fitzgerald said that he did not consider that there was never a mechanical action between matter and the ether, such as would be contradicted by the stated interpretation of the law of action and reaction. He mentioned several cases where an action of matter on the ether is unaccompanied by any reaction of a second portion of matter, such, for example, as the stress between the reflected light and a parabolic mirror, sending light out into interstellar space. Incidentally, Prof. Fitzgerald introduced a theory of what he called "corkscrewedness." A displacement current in a dielectric might be illustrated by a rotating corkscrew, in which there is both rotation and an apparent transition of something along the length of the corkscrew. Magnetic force might be explained as a change in the 'corkscrewedness" of the ether; if the spirals of the corkscrew were to swell out or to diminish to different radius there would be the analogue of a magnetic force. Steady currents in conductors might be explained without any variation of the "corkscrewedness" on account of the effect taking place in a closed conducting path. The necessary closed condition of a magnetic flux and the unnecessity of closedness of an electric flux would seem to point to the possibility of the magnetic effect being a continuous displacement along the line of the flux, and the electric effect being rotary. Dr. Lodge pointed out that, inasmuch as magnetic lines were necessarily closed, there was no ground for stating that no displacement takes place along their length.

In the absence of Lord Kelvin, two Papers entitled respectively "On the Piezo-Electric Property of Quartz," and "On a Piezo-Electric Pile," were read by Lord Rayleigh. These Papers deal with a potential difference set up in a dielectric or a pile of dissimilar metals by means of unequal distribution of pressures. A Paper by E. H. Barton dealt with some interference effects somewhat analogous to Newton's Rings, but exhibited by waves in wires. And a Paper by G. H. Yule dealt with the behaviour of thin layers of electrolytes when used with respect to waves of low frequency as thin plates are used with respect to waves having the frequency of light. The optical behaviour of quarter-wave and half-wave plates, and thin plates generally, was shown to take place.

In Section G the Papers of electrical interest discussed the well-worn subjects of "Refuse Destructors and Thermal Storage," and on the "Druitt-Halpin Scheme." No points of importance were raised in the discussions.

Saturday, September 16th.

Very few of the sections met for reading Papers on this day. Section A devoted itself to the discussion of matters of pure mathematics, such as "Agreeable Numbers," with disagreeably complicated theories attached to them, and to other questions of a mathematical nature. The "Note on the Magnetic Shielding of Two Concentric Spherical Shells," by Prof. Rücker, may perhaps be the foundation of a practical system of shielding. The two Papers by Prof. Fitzgerald, the one on "Equations for Calculating the Effect of a Long Tube as a Magnetic Screen," and the other on "Equations for Calculating the Effect of a Hertzian Oscillation on Points in its Neighbourhood," are beyond the radius of activity of most electricians, and their chief interests were mathematical. A considerable portion of the audience took this opportunity of wandering into the chemical and physical laboratories, where a good show of interesting apparatus was provided. Among the exhibits we noticed a number of instruments lent by the Cambridge Scientific Instrument Company, including a Callender electrical pyrometer. This consisted of a resistance box, batteries, an indicator, and a long steel tube containing a platinum thermometer, for insertion into furnaces or other places where a high temperature is to be measured. This firm showed a "tromometer," an instrument for recording earth tremors by means of a mirror and a beam of light. Several photographs of flying bullets were shown by Prof. Boys, and inductoscripts by the Rev. F. J. Smith. This photographic process is now of some interest, as it has been brought to a point at which it promises to be of practical value as a printing process. Messrs. Nalder Brothers had on view a number of instruments, including an optical bench and a high-resistance galvanometer made to Dr. Oliver Lodge's design, together with other apparatus which we have already described. Sir David Salomons, Messrs. Pyke and Harris, and Mr. Paul contributed specimens of electical apparatus.

Monday, September 18th.

Electrical interests were mainly concentrated in the proceedings of Section G on this day. In this section the list of Papers down for reading was headed by a short Paper by Mr. Gisbert Kapp, on "The Relative Cost of Conductors with Different Systems of Electric Power Transmission." The chief point in this communication was to show the fallacy of supposing that the use of a combined three wire return in two-phase alternate current transmission, instead of four wires in two separate circuits, will give any economy of copper in the mains. The author pointed out that, in the first place, there would normally be a current 40 per cent. greater in the third wire than in either of the other wires; but that, worse than this, the fluctuation of pressure in these other wires, resulting from tying the two circuits together, must necessarily put a great strain on the circuit, and would therefore limit the working pressure. When the limits of safe pressure in the mains alone were considered — the rest of the plant being assumed capable of supporting the limit—it was found that the relative costs of copper in the mains was as follows, mains for continuous current being taken at 100:—

Single phase, two wires ...	200	Double phase, three wires...	290
Double phase, four wires...	200	Three phase, three wires ...	150

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This result shows greatly in favour of the three-phase three-wire system of transmission, at least, insofar as the power has to be transmitted in bulk and not distributed. Although all these figures for alternating currents are higher than the one for continuous currents with two wires, yet the fact that it is impracticable on other grounds (commutator flashing, &c.) to use very high continuous pressures will lead to the conclusion that the best system in point of view of economy of copper is the three-phase three-wire system; and that coupling the two return wires in the two-phase four-wire system will not cause a saving in copper, but increased expenditure.

In the absence of Mr. A. T. Snell, his Paper on the "Utilisation of Water-Power by Electricity" was read by Prof. Robinson. In the discussion which resulted Prof. Unwin observed that the statement that water power was, on favourable mill sites, dearer than coal or fuel of any kind was wrong; and that in such cases it would probably be found that the expenses were almost nominal, as low as £1 per horse-power per year, for example. Mr. Lupton said he thought that this country abounded in water mills, many of which, however, had been abandoned. Several speakers commented on the necessity of stating the actual costs of an English water-power plant, such as Mr. Snell advocated. Mr. Carter criticised the conditions of average English mill sites, and remarked that they were not in general financially utilisable, when the great prime cost of the plant was considered. English conditions generally resulted in inefficient working. The President called attention to the prospect of exhaustion of the coal measures (if the strike does not last too long), and observed that we should then have to depend on water-power and wind-power. He suggested that instead of inefficient chemical storage cells it might be better to set our dynamos to decompose water and compress the hydrogen and oxygen in steel cylinders at a great pressure.

The third Paper dealt with a "New Form of Variable Power Gear for Electric Motors," invented by Mr. W. Worby Beaumont. This is a modification of the gear described in *The Electrician*, Vol. XXX., page 564. While Mr. Kapp thought that the invention was mechanically practicable, Prof. Hele-Shaw remarked that his experiences of epicyclic gear in other applications were not sufficiently happy to allow him to recommend it, and suggested that another form of gear might be incorporated in Mr. Beaumont's mechanism with good results. Mr. Carter considered the period of starting mentioned by Mr. Beaumont as being probably much shorter than would be actually experienced with a change in velocity ratio so great as that proposed. He also pointed out that the use of a higher ratio on up gradients would necessarily result in greatly reduced speed, if the speed of the motor was to remain sensibly constant.

The next Paper was read by Mr. W. B. Sayers, and dealt with his ingenious form of armature winding, and with the joint invention of his brother and himself for regulating feeders on a three-wire continuous-current system. A Paper by Mr. E. Payne, on a "Mechanical System of Electric Conductors," in which the use of fireproof mains was described, concluded the session for the day.

In Section A the meeting was principally concerned with the apparatus and methods of teaching physics in schools.

Tuesday, September 19th.

The proceedings of Section A opened on Tuesday with the report of the Electrical Standards Committee, which was read by Prof. Carey Foster. The unit ohm is defined as the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice, 14·4521 grammes in mass, of constant cross sectional area, and of a length of 106·3cms. The relation between the B.A. unit and the ohm is such that 1 B.A. unit equals 0·9866 ohm. A table of tested coils is given in the report. The committee was reappointed, with a grant of £25. Following this report came an allied Paper by Prof. Viriamu Jones "On Standards of Low Electrical Resistance." Prof. Jones advocated the direct determination of low resistance from an absolute method, known as the Lorenz method, by means of mutual induction with currents of known frequency; and he considered that low resistance standards might be more accurately derived in this way than by derivation down from a unit ohm. He had, however, encountered some difficulty in regard to the electrically propelled tuning fork, as he found that its frequency was liable to a small settled change if it was stopped and restarted. Prof. Lodge considered that the electrically propelled tuning fork should be compared with a free fork both at the beginning and the end of the test; he had not experienced any settled change of frequency in the former, as in all his experiments he had been careful to avoid stopping the fork. Prof. Jones replied that in the present instance it was impossible to avoid stopping the electrically propelled fork. Mr. Glazebrock considered that it might be well as a theoretical standard to adopt the expensive and complicated mutual induction method advocated by Prof. Jones; but that for all practical purposes of a standard, he preferred to recommend the mecury column, as being much more easy of determination.

Mr. F. H. Nalder described the Carey-Foster apparatus, which was illustrated in our report of the meeting of the Physical Society on June 23rd.

Prof. Oliver Lodge described a new galvanometer for physiological research; and a discussion on methods of increasing the sensitiveness of galvanometers followed.

Prof. Lodge made a "Supplementary Note on the Ether," being some thoughts suggested by a criticism on his Paper on Friday. Mr. Cowper Ranyard had proposed to him the difficulty that, if matter exerts no mechanical action on ether, it is not easy to explain the action of dust particles in polarisation of light. Dr. Lodge observed that the action of the dust particles was not mechanical but electrical. Lord Rayleigh observed that there was no more difficulty in reality in connection with the action of dust than in the action of any refracting medium, and that if the one optical effect was mechanical so would be the other. Excitement was momentarily raised by a clamour for an exact definition of the distinction between mechanical and electrical action; which definition, however, neither Prof. Lodge nor any other *savant* seemed able to give, save that there *was* a difference, and that "electrical" meant just what everyone meant by electrical. The crux of the matter seemed to exist in the necessity for exact definition of terms.

In the absence of Mr. A. B. Basset, his Paper "On the Publication of Scientific Papers" was read by Mr. Larmor. The Paper criticised the formation of a central organ, and advocated supplying each author with a large number of free copies of his Paper, and the development of some existing organ, such as *Nature*, into a sort of compendium of abstracts of physical Papers. It also recommended the co-operation of the various scientific societies for the publication every three or four years of a digest of Papers. Mr. Swinburne remarked that the present system was admittedly and undoubtedly bad, that indexes only gave one a list of Papers which, very often, it was difficult or impossible to procure, that journals followed one another like sheep in the matter of publishing and re-publishing again and again some chance Paper, while better Papers were often neglected by them all, and advocated sending Papers to the Physical Society, which supplied authors with a large number of free copies of their Papers. Very few of those present could have heard Mr. Swinburne's delightful remark after taking his seat: "The best way," said he, *sotto voce*, "would be to send round a monthly post-card containing all that is of any use in physical science for the month." Prof. Fitzgerald objected to indexing, because an index only gives one a stone when one is crying for bread; abstracts are better because one gets a little bread with the stone. To expect the proprietor of a successful journal to give up his interests in order to "further science" by putting into his Paper all the physics of the time, would be like asking a man to walk out of his house in the cause of science. Lord Rayleigh announced that a committee of the Royal Society with an open mind was being appointed for the consideration of the matter.

In Section A a Paper was read by Prof. J. J. Thomson on "A New Form of Air-Pump."

Wednesday.

There were no electrical Papers down for reading in either Section A or G on Wednesday.

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ON THE PIEZO-ELECTRIC PROPERTY OF QUARTZ.*

BY LORD KELVIN.

In the present communication we shall consider only a perfect hexagonal prism. The sides of the prism may be, and generally are, unequal in nature; but the angles are all exactly 120deg. We have three planes of symmetry, which for brevity I shall call the diagonal planes, being planes through the opposite edges of the prism. We have also three other planes of symmetry, which for brevity I shall call the normal planes, being planes perpendicular to the pairs of parallel faces.

In the brothers J. and P. Curie's beautiful instrument for showing their discovery of the piezo-electric property of quartz, a thin plate of the crystal about half a millimetre thick, I believe, is taken from a position with its faces parallel to any of the three normal planes of symmetry, its length perpendicular to the faces of the prisms, and its breadth parallel to the edges. The sides of this plate are, through nearly all their length, silvered by the chemical process to render them conductive, and are metallically connected with two pairs of quadrants of my quadrant electrometer. In an instrument which has been made for me under Mr. Curie's direction, the silvered part of the plate is 7cm. long and 1·8cm. broad. A weight of 1 kilogramme, hung upon the plate placed with its length vertical, causes one side to become positively electrified and the other negatively.

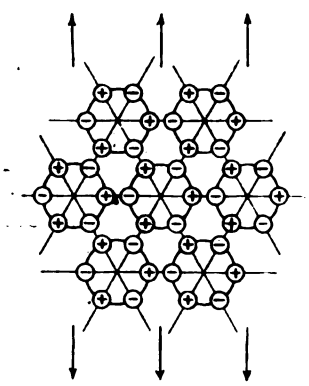

FIG. 1.

Electric eolotropy of the molecule, and nothing but electric eolotropy of the molecule, can produce the observed phenomena. The simplest kind of the required electric eolotropy which I can imagine is as follows:—For brevity, I shall explain it in relation to the chemical constitution which, according to present doctrine, is one atom of silicon to two atoms of oxygen. The chemical molecule may be merely SiO_2 for silica in solution, or it may consist of several compound molecules of this type, grouped together; but it seems certain that in crystallised silica (in order that the crystal may have the hexagonally eolotropic piezo-electric property which we know it has) the crystalline molecule must consist of three SiO_2 molecules clustered together, or must be *some* configuration, three atoms of silica and three double atoms of oxygen combined.

The diagram (Fig. 1) shows a crystalline molecule of this kind surrounded by six nearest neighbours in a plane perpendicular to the axis of a quartz crystal. Each silicon atom is represented by a + (plus), and each oxygen double atom by − (minus). The constituents of each cluster must be supposed to be held together in stable equilibrium in virtue of their chemical affinities. The different clusters, or crystalline molecules, must be supposed to be relatively mobile before taking positions in the formation of a crystal. But we must suppose, or we may suppose, the mutual forces of attraction (or chemical affinity) between the silicon of one crystalline molecule and the oxygen of a neighbouring crystalline molecule to be influential in determining the orientation of each crystalline molecule, and in causing disturbance in the relative positions of the atoms of each molecule, when the crystal is strained by force applied from without.

* Abstract of a Paper read before Section A of the British Association, and to be published in full in the *Philosophical Magazine*.

Imagine now each double atom of oxygen to be a small negatively electrified particle, and each atom of silicon to be a particle electrified with an equal quantity of positive electricity. Suppose now such pressures, positive and negative, to be applied to the surface of a portion of crystal as shall produce a simple elongation in the direction perpendicular to one of the three sets of rows. This strain is indicated by the arrow-heads in Fig. 1, and is realised to an exaggerated extent in Fig. 2.

This second diagram shows all the atoms and the centres of all the crystalline molecules in the positions to which they are brought by the strain. Both diagrams are drawn on the supposition that the stiffness of the relative configuration of atoms of each molecule is slight enough to allow the mutual attractions between the positive atoms and the negative atoms of neighbouring molecules to keep them in lines through the centres of the molecules, as Fig. 1 shows the undisturbed condition of the system, and Fig. 2 for the system subjected to the supposed elongation. Hence two of the three diameters through atoms of each crystalline molecule are altered in direction, by the elongation, while the diameter through the third pair of atoms remains unchanged, as is clearly shown in Fig. 2 compared with Fig. 1.

Remark, first, that the rows of atoms perpendicular to the direction of the strain are shifted to parallel positions with

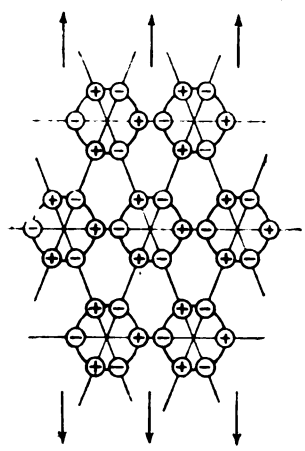

FIG. 2.

distances between the atoms in them unchanged. Hence the atoms in these rows contribute nothing to the electrical effect. But, in parallel to these rows, we find two pairs of atoms whose distances are diminished. This produces an electric effect which, for great distances from the molecule, is calculated by the same formula as the magnetic effect of on infinitesimal bar-magnet whose magnetic moment is numerically equal to the product of the quantity of electricity of a single atom into the sum of the diminutions of the two distances between the atoms of the two pairs under consideration.

Instead of the silicon atoms marked + in the diagram let us substitute globes of polished zinc; and instead of the double-oxygen atoms marked − let us substitute little globes of copper well oxidised (polished copper, heated in air till it becomes of a dark slate-colour). Let us suppose all the six atoms of each compound molecule to be metallically connected, and all the molecules insulated from one another. We are not concerned with conceivable permeation of electricity by conductance through the crystal; and therefore we must suppose the total quantities of electricity on each crystalline molecule to be zero. Let the circle of each compound molecule in the diagram be a real exceedingly thin stiff ring of metal, no matter what kind of metal, and let each of the six atoms be a bead (a perforated spherule), whether of zinc or of copper, moving frictionlessly on it. Thus we have, in idea, a working model of an electrically eolotropic crystalline molecule.

Consider now two simple elongations in the direction shown by the arrow-heads A in Fig. 3. These two elongations produce electro-polarisations with axes and signs indicated by *a a* and *b b* respectively. The resultant of our present two simple elongations is clearly a single simple elongation in the

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line K′ O K, bisecting the angle between them, and of magnitude equal to $\sqrt{}$ three times the magnitude of each of them, as is easily proved by the elementary geometry of strain. Hence an elongation in the direction K′ O K does not produce zero of electric effect. On the contrary, elongation in the line K′ O K produces an electro-polarisation which is the resultant of the equal polarisations indicated by $a\,a$ and $b\,b$, which, as it bisects the angle b O a, is in a line inclined at 45deg. to O′ K, the line of the elongation. In fact, simple elongation in any direction perpendicular to the principal axis of a quartz crystal produces electro polarisation; and it is only when the lines of two simple elongations are coincident with one another, or are perpendicular to one another, that the resultant of their electro-polarisations can be zero.

A most important contribution to knowledge of the electric properties of crystals has been made by Röntgen, and by Friedel and J. Curie, in independent investigations proving that the irregular electrifications of the corners of quartz crystals, which had been observed by many observers as consequences of heatings and of returns to lower temperatures, are wholly due to mechanical stresses developed by inequalities of temperate in different parts of the crystal. Those phenomena are therefore truly *piezo electric*, and are not at all "pyro-electric" like the electric property of tourmaline which is due to change from one temperature to another, each the same throughout the crystal. The very important and interesting discovery thus made by Röntgen and by Friedel and Curie, is, as they have pointed out, available also to explain the perplexing and seemingly paradoxical statements regarding positive

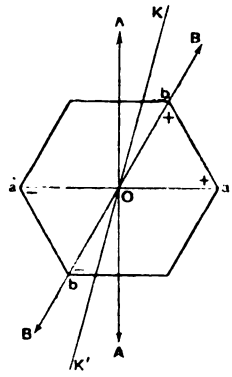

Fig. 3.

and negative electrifications of corners and hemihedral facets at opposite ends of the four long diagonals of crystals of the cubic class, and of cubes of boracite, which had been given by previous observers and writers, and which have not yet disappeared from elementary treatises on Mineralogy, Electricity, and General Physics.

ON A PIEZO-ELECTRIC PILE.*

BY LORD KELVIN.

The application of pressure to a voltaic pile, dry or wet, has been suggested as an illustration of the piezo-electric properties of crystals, but no very satisfactory results have hitherto been obtained, whether by experiment or by theoretical considerations, so far as I know. Whatever effects of pressure have been observed have depended upon complex actions on the moist, or semi-moist, substances between the metals and electrolytic, or semi-electrolytic and semi-metallic, conductances of the substances. Clearing away everything but air from between the opposed metallic surfaces of different quality, I have made the piezo-electric pile which accompanies this communication. It consists of 24 double plates, each 8 cm. square, of zinc and copper soldered together, zinc on one side and copper on the other. Half a square centimetre is cut from each corner of each zinc plate, so that the copper square is left uncovered by the zinc at each of its four corners. Thus each plate presents on one side an uninterrupted copper surface, and on the other side a zinc surface, except the four uncovered half-square centimetres of copper. A pile of these plates is made, resting one over the other on four small pieces of india-rubber at the four copper corners. The air-space between the opposed zinc and copper surfaces may be of any thickness, from half a millimetre to three or four millimetres. Care must be taken that there are no minute shreds of fibre or dust bridging the air-space. In this respect so small an air-space as half a millimetre gives trouble, but with three or four millimetres no trouble is found.

The lowest and uppermost plates are connected by five wires to the two pairs of quadrants of my quadrant electrometer, and it is generally convenient to allow the lowest to lie uninsulated on an ordinary table and to connect it metallically with the outer case of the electrometer.

To make an experiment (1) connect the two fine wires metallically, and let the electrometer needle settle to its metallic zero.

(2) Break the connection between the two fine wires, and let a weight of a few decigrammes or kilogrammes fall from a height of a few millimetres above the upper plate and rest on this plate. A startlingly great deflection of the electrometer needle is produced. The insulation of the india-rubber supports and of the quadrants in the electrometer ought to be so good as to allow the needle to come to rest, and the steady deflection to be observed, before there is any considerable loss. If, for example, the plates are placed with their zinc faces up, the application of the weight causes positive electricity to come from the lower face of the uppermost plate, and to deposit itself over the upper surface of plate and weight and on the electrode and pair of quadrants connected with it.

* Abstract of Paper read before Section A of the British Association.

THE AUTOMATIC BALANCE OF RECIPROCATING MECHANISM.*

BY W. WORBY BEAUMONT, M.INST.C.E.

In this Paper the author pointed out that in most cases of vibration in machinery, whether of rotary or reciprocating forms, the vibration was due to the restriction of the motion which would naturally occur if the nominally stationary parts were free to act under the influence of the disturbing force. To bring about such restriction, and to prevent the movement of the stationary parts, it is usual to balance the moving parts with care, and in most rotating mechanism this can be done with success. It is, however, very difficult in reciprocating mechanism, and in many cases cannot be achieved. The push and pull imparted to and causing reciprocation in the thing to be moved, is equally but oppositely imposed on that which transmits the push and pull. The latter has, therefore, to be so constructed that it can oppose the movement which the operative force tends to bring about.

When the mechanical means adopted consist of a crank, or the like, and connecting rod, it becomes necessary to balance the crank and connecting rod, and often to make the so-called balance-load kinetically superior to the load balanced; in other words, to make the inertia of the balancing parts greater than that of the parts balanced, the excess representing part of that of the reciprocating thing to which motion is communicated. This practice sometimes improves the working of the machinery, but it involves framing of great strength, and mechanism with large bearings and great accuracy of fitting, and does not materially reduce the vibration set up in buildings or floors containing the machinery.

It was shown in the Paper that troubles brought about by this vibration might be completely avoided, and that at the same time the strength, cost, and power hitherto necessary might be all reduced by completely reversing the usual proceeding. The author showed that the cause of this vibration might be employed to effect the working of the reciprocating machinery. Instead of balancing operating parts he purposely puts them out of balance, and instead of attaching them to

* Abstract of a Paper read at the British Association in Section G.

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the fixed or stationary parts he attaches them to the moving part. In this way the unbalanced motor parts are automatically balanced by setting up as much motion in the thing to be moved as is necessary to absorb the inertia of motion or the momentum of the unbalanced thing in every part of its path. All vibration of the supporting parts is thus avoided, and that which usually sets up vibration is converted into a vibromotor. The Paper was illustrated by working models.

SELF-EXCITING ARMATURES FOR CONTINUOUS-CURRENT DYNAMO ELECTRIC MACHINES AND COMPENSATORS FOR LOSS OF PRESSURE IN FEEDERS OF ELECTRIC SUPPLY SYSTEMS.*

BY W. B. SAYERS.

The object of this Paper is to bring before your notice a new construction of continuous-current dynamo machine, in which that portion of the winding of the armature which for the time being is not subject to the inductive action of the magnetic field is utilised. (1) To entirely produce the requisite flux in the magnetic system. (2) To reinforce the flux produced by other means, such as shunt coils. These conditions are attained practically by the use of a device by which it becomes practicable to fix the diameter of commutation of the armature in the necessary position relatively to the neutral diameter to produce this result. The device referred to, and the mode of its action, was described by the author in a Paper read before Institution of Electrical Engineers on May 11th last, and which will be found in No. 107, Vol. 22, of the *Proceedings* of that Society.

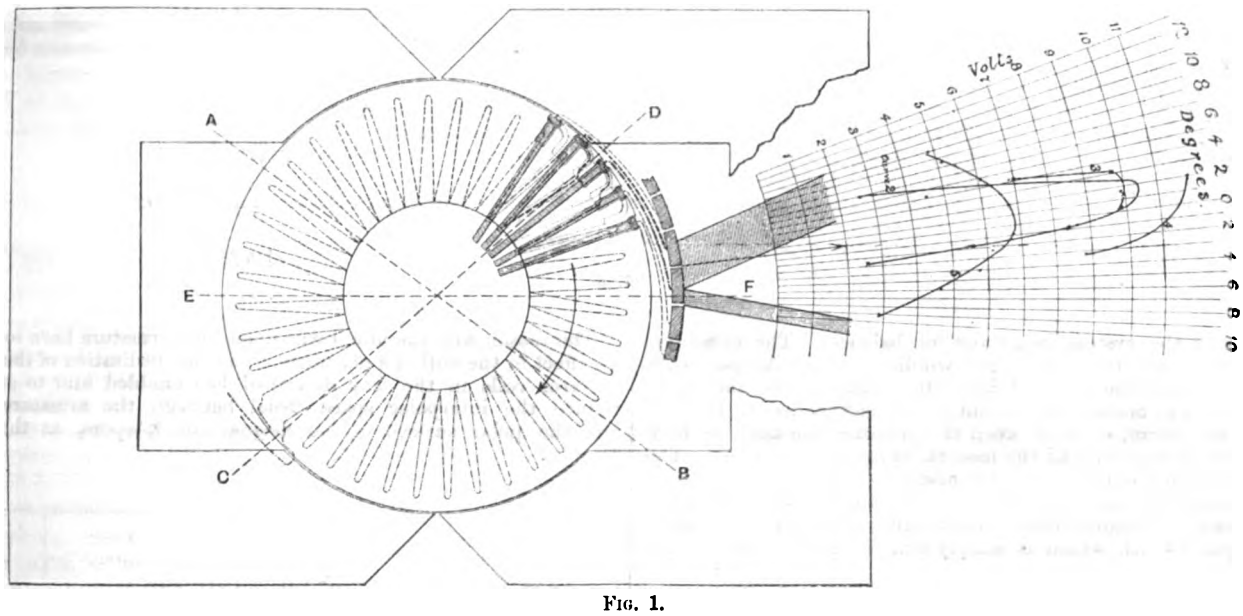

FIG. 1.

Fig. 1 represents diagrammatically a machine in which, in addition to the E.M.F., the magnetic flux is entirely produced by the armature winding. The portions of the winding lying at any time between A and D and C and B are generating E.M.F. while the current in the portions lying any time between A and C and B and D provides the necessary magnetising force. The condition under which this result is attained is that the current enters and leaves the armature at points approximately on the diameter C D, the direction of rotation being that indicated by the arrow. Those familiar with dynamo electric machinery will observe that the diameter C D is angularly displaced relatively to the diameter E F, in a contrary direction to that which has hitherto been the case in practice.

Consider an ordinary series-wound dynamo. Let the connections between the field coils and the armature be changed so as to send the current through the field coils in the opposite direction to that intended, the result would be that the machine would not excite, for the reason that any current generated by the armature would reduce the magnetisation of the system instead of augmenting it. When the diameter of commutation is situate in front of the neutral diameter, which is the case in ordinary practice ; that is, between the neutral diameter and A B (Fig. 1), the effect of the portion of the armature winding lying between the diameter A B and such diameter of commutation is of the same character as that of the field coils of the series machine when they are coupled up in the wrong direction ; that is, it tends to reduce the magnetisation of the system. But shifting the diameter of cummutation backwards proximately to the position A, B, is equivalent to changing the connections of the series coils back to the correct relation to the armature, when they tend to build up or augment the magnetisation of the system instead of to diminish it. In the armatures of the machines as constructed, the connections between the armature winding and the commutator are brought over the core of the armature in such a position, relatively to the points in which they are connected to the winding, that those carrying the momentary current as they pass the brushes are behind the diameter of commutation ; thus, by properly setting the brushes, the connections to the commutator are just under the tip of the pole-piece which is behind the neutral diameter, at the time when the momentary current passes through them to the brushes, while the diameter of commutation is a little in front of this position.

Under these conditions the section of the armature which is passing through the diameter of commutation having passed out of the intense part of the magnetic field, can be effectively reversed (or commutated) by the differential inductive action of the field upon the commutator connections.

It is evident that in a machine such as we are considering any movement of the brushes will alter the number of turns of the armature winding which are effective in magnetising the system, and thus vary the E.M.F. of the machine. In Fig. 1 some curves are given showing the performance of the machine with the brushes in different positions. If the pointer drawn through the larger brush is supposed to move with the brushes, while the curves remain stationary, the pointer will indicate the E.M.F. which would be generated :—In the case of curve 2, when running at the speed of 850 revolutions per minute, with an external resistance in circuit of 0·03 ohm ; curve 3, with speed 1,000 revolutions per minute, and external resistance 0·038 ohm ; curve 4, with one turn of series-winding around each keeper, speed 1,000 revolutions and external resistance 0·045 ohm ; and curve 5, when a constant current of 200 amperes is forced through the armature, with speed 1,000 revolutions per minute.

The machine which is illustrated in Fig. 1 was designed for, and is now in use as, a compensator, for the loss of pressure in the feeders connecting the new Midland Hotel with the Midland Railway Company's generating station at Bradford. The machine is situated in the engine-room, and is coupled direct to a shunt-motor and driven at a constant speed, and the main current of the hotel is passed through the armature. Now the loss of pressure in the feeders for direct-current supply is proportional to the current flowing, as is well known, and on referring to Fig. 2, which is the characteristic of the machine, it will be seen that the E.M.F. generated is almost exactly proportional to the current throughout the range of values given. Thus, the machine being properly related to the resistance of the feeders, the loss of pressure caused by whatever current is flowing is exactly compensated.

The author, in conjunction with his brother, Mr. J. Sayers, of Derby, has recently designed and constructed, at the works of

* Paper read before the British Association in Section G.

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Messrs. Mavor and Coulson, Bridgeton Cross, Glasgow, two sets of compensators, having self-exciting armatures, for the Midland Railway Company's electric lighting station at Derby. The problem here was not so simple as that at Bradford. The three-wire system being in use at Derby, it became necessary to provide against the disturbance produced by the loss of pressure in the so-called neutral wire when a current is flowing in it, owing to the two sides of the system being out of balance. The difficulty, however, was met by providing a winding on the keepers connected in series with a neutral wire, the winding being put on in such a way as to modify the amount of pressure added to the two sides of the system, so as to keep the pressure constant on both sides at the distant end of the feeders under all conditions. The photograph represents one of these machines.

Mr. Swinburne has pointed out to the author that with his device a motor can be designed having no winding whatever on the main moving part, which would be simply a mass of iron; this would involve the use of revolving brushes, but as there would be no necessity of shifting the diameter of commutation with varying load, there would be no objection whatever to this.

The advantage of such a motor for tramcar work will be readily appreciated.

I pass now to machines in which the idle armature coils—idle that is as regards producing E.M.F., are utilised to produce on a shunt machine the same effect as series coils on the magnets would have, that is, to keep the pressure constant with varying load. Figs. 3 and 4 are characteristic of such machines, which will be self explanatory, I need only call particular attention to curve 1 Fig. 4, which represents the performance of the machine when the brushes are set with a forward lead in the ordinary way, and the idle armature coils exercise their up to the present usual action of pulling down the magnetisation.

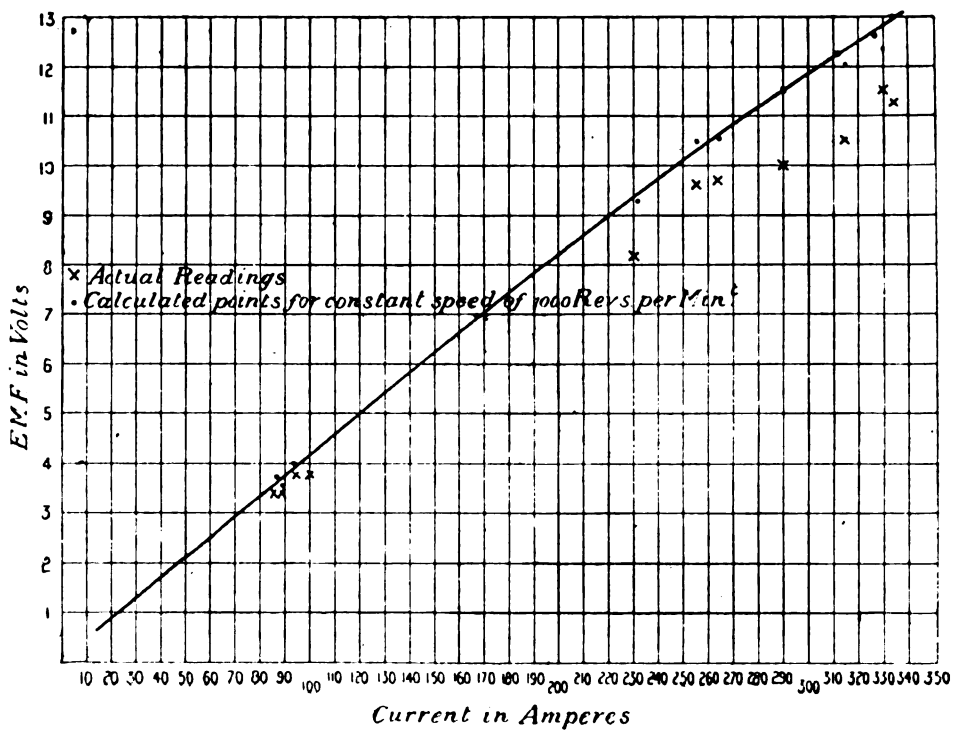

FIG. 2.

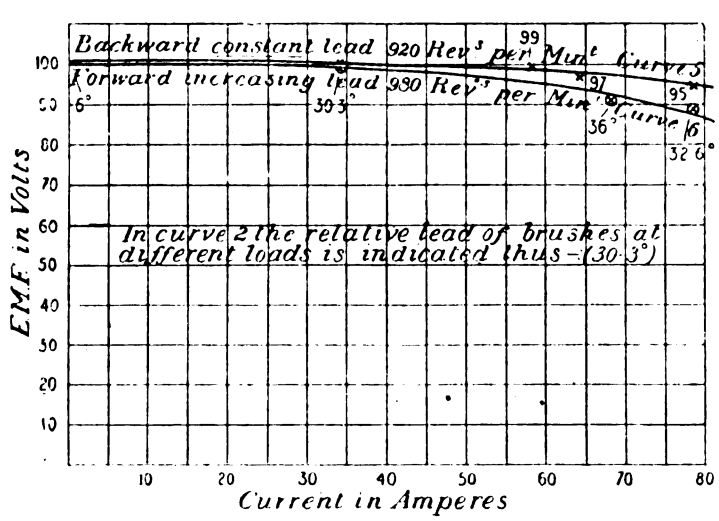
Backward constant lead 920 Revs per Min. Curves
Forward increasing lead 980 Revs per Min. Curves
6°
30·3°
36°
32·6°
In curve 2 the relative lead of brushes at different loads is indicated thus – (30·3°)
E.M.F in Volts
Current in Amperes

FIG. 3.

The reason why the idle turns upon the armature have so large an effect in the author's machines is that his utilisation of the commutator coils in the way described has enabled him to greatly reduce the interpolar space usual between the armature core and the polar surface of the magnets or keepers, as the case may be.

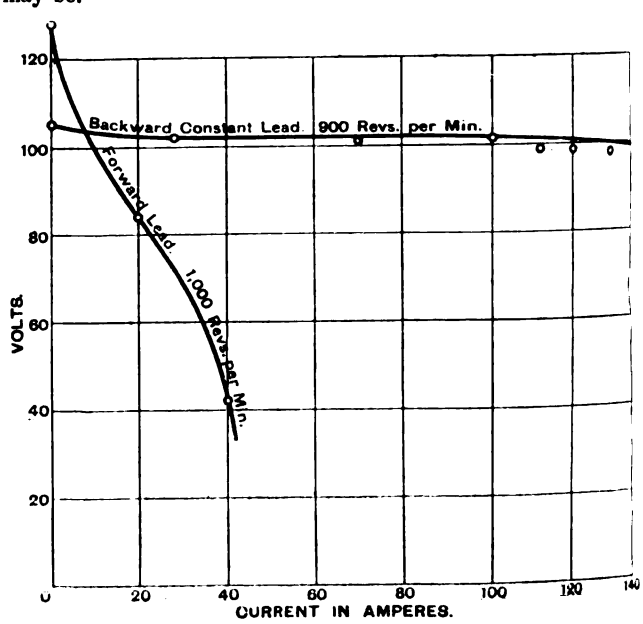

FIG. 4.—10¼ by 12 Dynamo. Design No. 16. Machine No. 324.

The effect of reducing this space is to reduce the magnetising force necessary, but as the number of idle turns are not reduced they become of very much greater importance. As a result of the reduction in magnetising force required the author is able to reduce the weight and cost of dynamo machines to a considerable extent. To show this an illustration is appended, taken from the appendix to the Paper already referred to, read before the Institute of Electrical Engineers.

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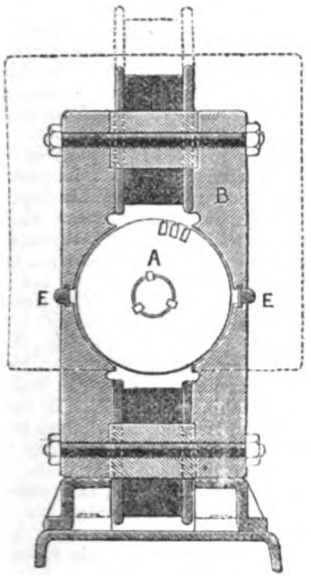
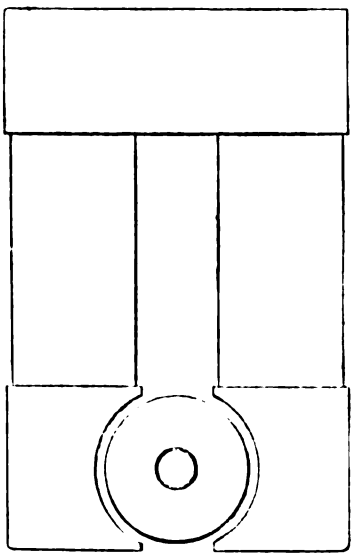
Figs. 5 and 6 represent respectively to the same scale similar views of a machine of the author's design, and also the celebrated Edison-Hopkinson machine described before the Royal Society some years ago, both machines being for the same output and the same speed. The tables below the figures give the electrical data and some of the more important items of cost of the materials of the two machines.





Scale 1 inch = 1 foot.

FIG. 5. FIG. 6.

ELECTRICAL DATA.

Armature.

—	Edison-Hopkinson.	Sayers.
Cross section of conductor	0·065 sq. in.	0·075 sq. in.
Current density	2,460 amperes per sq. in.	2,150 amperes per sq. in.
Resistance at 100°F.	0·008 ohm.	0·0067 ohm.
„ of two reverser bars	—	0·001 „
Total resistance between brushes	0·008 ohm.	0·0077 „

Field-Magnets.

Resistance of magnet coils.	Edison-Hopkinson.	Sayers.
Say, 15,000ft. No. 13 wire	16·93 ohms.	—
If single magnet, 14,000ft. No. 19 wire	—	82 ohms
If double magnet, 14,000ft. No. 17 wire	—	43 „
Current	6 amperes	—
If single magnet	—	1·28 amperes
If double magnet	—	2·56 „
Ampere-turns in shunt coils	19,600	3,600

WEIGHTS AND VALUES.

—	Edison-Hopkinson.			Sayers.		
	Weight.	Rate.	Value.	Weight.	Rate.	Value.
			£ s. d.			£ s. d.
Armature discs	3·7cwt.	32s.	5 18 0	4·7cwt.	32s.	7 10 0
Armature conductor	60lb.	9d.	2 5 0	67lb.	1s.	3 7 0
Reverser bars	—	—	—	11·5lb.	9d.	0 8 8
Magnet cores	31·7cwt.	12s.	19 0 0	12·2cwt.	12s.	7 6 0
Magnet wire	410lb.	9d.	15 6 0	141lb.	10d.	5 17 6
			42 9 0			24 9 2
Total weights of parts enumerated above	39·5cwt.			18·8cwt.		

HALIFAX AND BERMUDAS CABLE COMPANY (LIMITED).—The fourth annual meeting was held on Wednesday at the offices, 33, Old Broad-street, E.C., when the Directors' report and the balance-sheet were adopted unanimously. The result of the working for the year ended June 30th showed a profit of £1,717. 8s. 5d., which, with balance from previous year of £1,681. 19s. 7d., in all £3,399. 8s., was applied to writing off the debenture interest and other expenses prior to opening of cable for traffic.

NOTE ON THE UTILISATION OF WASTE WATER-POWER BY ELECTRICITY.*

BY ALBION T. SNELL.

On the Continent water-power is extensively used for driving electric plants, but in Great Britain, for a similar purpose, power is usually derived from the combustion of coal.

This difference in practice is partly the result, no doubt, of the relative supply of water-power in the neighbourhood of places where electric plants would prove commercially profitable; but it is also largely due to the relative cost of fuel. We do not possess abundant natural sources of water-power in or near our large manufacturing districts, and even if we did it is not probable that with coal at the average price of the last ten years, water-power would prove much cheaper when the capital invested, interest, and cost of maintenance of the electric plant were taken into consideration. But we may with reason pause to ask two questions: Will coal at such a price be always obtainable? And do we make the most of such water-power as we have and can profitably use? Let us look at the second question first. Liverpool is supplied with water from Lake Vyrnwy, in North Wales, the total difference of head being about 500ft. There must be a considerable quantity of power in the conduit. Is any of it utilised? And if not, does the reason lie in the fact that fuel at present is so cheap? Could the Manchester Water Works, which form a magnificent series of artificial lakes, be utilised to drive turbines and give electric energy for lighting the various towns in their vicinity? Again, the watershed behind Greenock has a fall of many hundred feet, and the water is only partly utilised to drive mills. These are only a few instances in which water-power might, perhaps, be advantageously used for driving turbine-dynamos. There are, of course, numerous mountain streams which could be dammed, and thus converted into reservoirs for feeding turbines.

England has been so prosperous in the past by reason of large supplies of coal, hitherto cheap and certain, that the consumers of power have scarcely realised the necessity of any change, and can with difficulty be brought even to contemplate the utilisation of waste water-power. On the Continent, however, coal is found in only a few districts, and fuel is generally dear in comparison with the prices current in Great Britain, and dearer still in relation to local wages and prices. Necessity has thus prepared Swiss, German, and Italian manufacturers, for a radical innovation, which gives them a cheaper power by utilising mountain streams. It is no mere figure of speech to say that natural obstacles in the way of trade competition have led to the development of this important branch of engineering on the Continent, while the very prosperity of Great Britain has tended to hinder progress in this direction. We may ask ourselves in all seriousness whether the present price of coal is likely to be maintained, and whether it would not be wise to make the most of such water power as we have by using it as an adjunct to, if not as a substitute for, coal. This is quite possible in many places, since power can be transmitted electrically at high pressure for distances of 20 miles or so with a loss not exceeding from 15 to 20 per cent.

The author then proceeds to describe several examples of the use of water-power on the Continent.

In England there are only a few installations which derive their power from water, such as the small central station for lighting Lynmouth and Lynton, and a few private installations. A scheme, on a large scale, for electrically lighting Worcester by means of power derived from the River Severn is in hand, and will, no doubt, lead to similar plants.

One of the most important instances of the application of water-power for electric power transmission in Great Britain at present is that at the Greenside Silver Lead Mines in Cumberland, which was designed by the writer about three years ago in conjunction with the mine manager, Mr. Borlase.

On the east slopes of Helvellyn lies a small natural lake called the Red Tarn, and on the north-east the impounded water of Keppel Cove. Between the two waters rises the hill of Catstycam, at the base of which the two overflows join, and near to which the Greenside Silver Lead Mining and Smelting Company have erected their turbine-dynamo station. The water is led from an elevation of 1,750ft. above sea level, and flows through an open watercourse 1¼ miles in length to a large reservoir, from which it is conveyed down the hill-side for a distance of 360 yards in 15in. cast-iron pipes. The fall at the station is equivalent to a vertical head of 400ft., and the effective horse-power is about 200.

The generating station contains one of Gilkes and Co.'s vortex turbines of 100 H.P., driving a four-pole compound dynamo made by the General Electric Power and Traction Company. The house is large enough to duplicate this plant when necessary, and pipes, watercourses, &c., are already laid for this purpose.

* Abstract of a Paper read before the British Association in Section G, Nottingham, September, 1893.

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The electric current is conveyed by two bare copper conductors on poles for six furlongs, to where it enters the mine at an elevation of 1,850ft. above the sea level. The conductors from this point are insulated, and covered with lead. About three-quarters of a mile in the mine, or one and a-half miles from the dynamo, a 9-H.P. series motor is employed to wind ore from a set of sinkers. Further into the mine another quarter of a mile, and down 120 yards at the bottom level, is fixed another 9-H.P. motor, working a three-throw pump, forcing the water 360ft. in height.

About midway between these motors there is fixed a dynamotor, which reduces the pressure from 600 to 250 volts for working an electro-locomotive in the lowest day level of the mine, through which runs the water pumped from the 120-yards level and the whole of the water used by two hydraulic winding engines. Four horses formerly worked this level. The locomotive runs with 12 waggons, the total weight when loaded being 18 tons, and does the work of the four horses with the greatest ease. The conductors in the level are phosphor bronze wire, and the current is fed to the locomotive by four contact pulleys. The difficulties encountered in fixing this plant and wiring the level can only be appreciated by the practical man. All main stations in the mine are lighted by incandescent lamps in series of six.

The chief difficulty attending the use of water-power is the irregular and sometimes intermittent character of the supply, and hence it is necessary to exercise great care in judging the suitability of water for given work. This can be obviated to a large extent by building reservoirs and regulating the output according to the power required ; but when lighting forms an important part of the scheme, secondary batteries may be used most advantageously.

It will be gathered that the writer is fully aware the small water-power of Great Britain can never show results equivalent to those obtained on the Continent, yet there is undoubtedly much water-power wasted here that is capable of being profitably utilised. His object is simply to call attention to the improved means of utilising water-power by turbine-dynamos, and to suggest that prompt measures be taken to conserve as much power as possible by a proper attention to the building of dams and reservoirs wherever this may be feasible. And that such power should be used if convenient, to the exclusion of coal, and, if not so, as an auxiliary power, the steam plant being used as a stand-by as much as possible.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS : TUESDAY, SEPTEMBER 19TH.

On the resolution for the Post Office and Telegraph service, Mr. HENNIKER HEATON said that a grosser blunder had never been committed than for the Post Office to keep in their own hands the unproductive trunk telephone lines while they left the paying local lines in the hands of the private companies. He objected to the system of guarantees in connection with the establishment of local telegraph lines. The hon. gentleman then proceeded to comment on the rules laid down as to the charges for compound words. He submitted that the time had arrived when such anomalies should be put an end to. The public were so much irritated and worried by all the petty annoyances of the Telegraph Department that the Postmaster-General would suffer very little loss in revenue by allowing every compound word to be charged as one, and by putting an end to other petty grievances.

Sir A. ROLLIT spoke of the great interest which the municipalities had shown in the telephone, and considered that what was now proposed was not a restriction upon municipal action. It was not correct to say that the charge for the telephone was £20. When all the circumstances were taken into account he found that the average charge in London was £15. 0s. 7d., and in the provinces £8. 16s. 10d. He would not express an opinion as to whether a lower price would pay. His view was that the work should be done in the best form, in the belief that really good public service would in the end be most remunerative. The administration of the Department in this matter, both by the Postmaster-General and by his predecessor, had been such as to lead the National Telephone Company to desire nothing that was not fair and reasonable. Their desire was to consult the public interest, and he could assure the right hon. gentleman that in .the negotiations in regard to the agreement they would do their best with him to arrive at a right and fair conclusion.

Mr. A. C. MORTON said in his view the telephone companies wanted what was unfair and unreasonable. Their object was to secure by the aid of the Government a permanent monopoly. All he wished to say now was that the Act of last year was rushed through the House in a great hurry. He did not object to the Government purchasing the main lines, but he trusted that the Postmaster-General would do nothing to assist a monopoly. All he asked for was fair play.

Mr. A. MORLEY said the discussion had ranged over a variety of subjects, but he proposed to take the telephones first. He did not think he could fairly be asked to make a declaration of the policy of the Government on that question at the present moment. The recommendations of the joint committee which had been sitting would have to be carefully considered. He thought that the powers of the telephone companies to lay their wires ought to be subject to the sanction of the local authorities. The heads of agreement between the late Government and the National Telephone Company were drawn up and signed by his predecessor, and he thought a very considerable case would have to be made out to justify the House of Commons in departing from that agreement. The measure was the simple embodiment of a policy which was discussed more than once. With reference to the subject of competing telephone systems, he quite agreed that competition in the same area would destroy half the advantage of the invention. Parliament ought, therefore, to hesitate before sanctioning any arrangement under which there would be competing telephones in the same area. He now came to the schemes introduced under the late Government respecting Army Reserve men and telegraph messengers. The plan relating to the latter was that telegraph messengers who entered the service at the age of 13 or 14 should, upon reaching the age of 18, be turned out of the service unless they consented to serve with the colours for five years. If they consented to serve they were to have the right of re-entering the service as postmen at the end of five years. The reports which he received from postmasters of large towns were almost unanimous in declaring against this system. In these circumstances he would have incurred very considerable responsibility if he had allowed the new system to continue. The scheme which gave Army pensioners and Reserve men who wished to become postmen precedence over other applicants remained in full force. He thought the working of the rule would require watching, but at present he saw no reason to depart from it, and had no intention of doing so. With regard to telephone charges, comparison had been made between London and such towns as Stockholm and Melbourne. It would be fairer, he thought, that the comparison should be with towns like New York or Paris. In New York in business houses the charge was £50, in residences £37. In Boston the charges were £37 and £28, and in Philadelphia £25 and £21. In these three towns, therefore, which were smaller than London, the charges were considerably higher than here. It had been suggested that the charge for porterage in connection with telegrams might be done away with. In view of the fact that last year the loss in the Telegraph Department was very considerable, such a change could not be acceded to. In the course of the discussion some conundrums had been put to him respecting the charges for compound words in telegrams. He thought he might be excused if he did not answer them in detail. There were, doubtless, some anomalies, but it was difficult to lay down a general rule applicable to all cases. With regard to the extension of the postal telegraph service in the country, the last point to which he had to refer, he could quote some figures which would show that the department were doing their best to meet the increased demand. The number of additional telegraph offices opened in the year 1888-89 was 221 ; in 1889-90, 321 ; in 1890-91, 275 ; in 1891-92, 349 ; in 1892-93, 561 ; and this year, from April 1st to September 20th, 450. During the latter period of six months, therefore, a larger number of offices had been opened than in any full year preceding that period, except last year, and this was a proof that substantial progress was being made in this direction.

The resolution was then agreed to.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1893 Edition of "'THE ELECTRICIAN' ELECTRICAL TRADES' DIRECTORY AND HANDBOOK" contains over 1,000 pages, several new and handy features having been added. Price 7s. 6d., post free 8s. 3d. ; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

The 1894 Edition is in preparation, and will be published, as usual, in January. New names, alterations of addresses, &c., are received at any time, but the Directory blanks and circulars are not sent out until later in the year, in order that the most recent, and consequently the *correct*, addresses *only* shall appear in the book.

"DRUM ARMATURES AND COMMUTATORS."—This book, which is written by Mr. F. Marten Weymouth, and is the latest edition to *The Electrician* Series, is now ready, and will be sent direct by the publisher on receipt of the published price, 7s. 6d., or it may be obtained from any bookseller. A prospectus will be forwarded on application.

TENDERS INVITED.—The Corporation of Blackburn invite tenders for the supply and erection of machinery and plant for the electric lighting of the borough. There are seven separate contracts, as follows :—(1) Steam boilers and accessories ; (2) steam dynamos and accessories ; (3) travelling cranes ; (4) cables ; (5) conduits ; (6) accumulators ; (7) switchboards, &c. Plans may be seen, and full information obtained, on application to Mr. Thomas Barton, the electrical engineer, Ainsworth-street, Blackburn ; and tenders must reach Mr. Robert E. Fox, town clerk, not later than 12 noon on Friday, October 27th. Some further particulars appear in our advertisement columns.

——— Tenders are invited for the lighting by electricity of the Caledonia Foundry and Engine Works, Brasenose-road, Liverpool. All information can be obtained from the proprietors.

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TENDERS INVITED.—The Directors of the Gas Light and Coke Company announce in our advertisement columns that they are prepared to receive offers for the purchase of the Company's make of retort carbon at their several stations, for one year from the 30th inst. Offers should be sent in before October 3rd. Further particulars may be obtained from the chief office of the Company, Horseferry-road, Westminster, S.W.

——— The Directors of the Great Western Railway invite tenders for the supply, from November 1st next to October 31, 1894, of various stores, amongst which are telegraph instruments, telegraph apparatus, telegraph iron work, &c., telegraph drysalteries, carbons for electric light, telegraph poles, &c. These tenders must be sent in on or before Monday, October 2nd.

TENDERS ACCEPTED.—The Ealing Local Board have accepted the tender of the Callender's Bitumen, Telegraph and Waterproof Company (Limited) for the supply of the mains for the electric light installation, and that of Messrs. Paterson and Cooper for wiring the public buildings. The following are lists of the tenders sent in :—

For Mains.

Fowler-Waring Cables Company	£6.199	2	10
Callender's Bitumen, &c., Company (accepted)	6,291	8	8
Siemens Brothers and Co.	6,863	0	0
British Insulated Wire Company	7,570	7	8
Reid Brothers	8,190	19	0
Johnson and Phillips	8,336	6	0
W. T. Henley's Telegraph Works Company	8,924	11	10

For Wiring the Public Buildings.

Binko and Co.	684	18	6
Brown and Co.	700	0	0
Spagnoletti and Crookes	793	0	0
Paterson and Cooper (accepted)	795	16	2
Tayler-Smith Electric Company	842	0	0
Emanuel (A.) and Sons	853	15	0
Lund Brothers and Co.	871	4	6
Howard and Co.	875	18	0
Ronald A. Scott	903	0	0
Brush Electrical Engineering Company	920	11	9
Rashleigh Phipps and Co.	990	0	0
Rawlings Brothers	1,020	7	0
Johnson and Phillips	1,099	9	0
British Electric Light Company	1,119	0	0
Nicholson and Tyler	1,125	10	4
Thomas Digby	1,130	0	0
Julius Sax and Co.	1,149	18	9
Baily and Grundy	1,188	0	0
MacLellan and Co.	1,249	12	3
Roger Dawson	1,252	0	0
Crompton and Co.	1,259	0	0
Strode and Co.	1,277	15	3
S. Cutler and Sons	1,362	0	0
R. Verity and Sons	1,376	6	6
W. Mackie	1,611	5	3
Tickner and Partington	2,187	5	6

PLANT FOR SALE.—Messrs. Sharp and Kent announce in our advertisement columns that they have for sale a complete electric light generating plant, suitable for 300 16-c.p. lamps.

APPOINTMENT VACANT.—It will be seen by our advertisement columns that the Southampton Harbour Board require the services of an electrical mechanic to attend to the electric cranes and the electric lighting. Particulars can be obtained from Mr. A. H. Skelton, the clerk, up till Saturday, the 30th inst.

PERSONAL.—Mr. Walter James Smith, lately assistant in the Liverpool Corporation's electric laboratory, has been appointed electrical inspector for their district by the Toxteth Park Local Board.

LIQUIDATION.—A meeting of the National Telegraph Works Company (Limited) is to be held at Mr. James Rhodes's, 34, Waterloo-street, Birmingham, on the 27th prox., at 4 p.m., to receive an account of the winding-up.

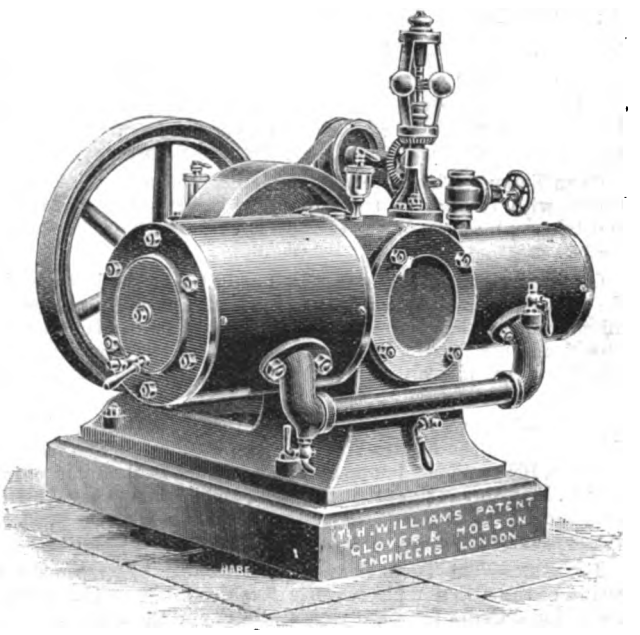
MESSRS. DRAKE AND GORHAM.—This firm carried out the temporary electric light installation in connection with the recent Primrose League demonstration at Haddon Hall, the seat of the Duke of Rutland. Four Crompton-Pochin arc lamps were arranged on the towers, affording light to a considerable distance in the extensive grounds.

ELECTRIC LIGHT LETTERS FOR ADVERTISERS.—These electric letters are formed of bright plated metal backings, of hollow section. Into these backings, glass tubes of uniform diameter and various lengths, enclosing a filament, are fitted. The appearance of the electric light advertisements or signs formed of these letters is of an unusual and striking character. They are most especially suited for theatres, railway stations, exhibitions, restaurants, hotels, shops, advertisements in tunnels, underground railways, and every other place where an ordinary advertisement would be utterly useless. These electric light letters mounted on a skeleton frame, and suspended within the window, afford a brilliant advertisement and a brilliant light, thus rendering any other form of window lighting wholly unnecessary. The Electrical Advertising Syndicate (Limited) are the proprietors of the invention, and are already erecting these signs in London. The letters in question have been designed by Mr. Réné Upward, who is consulting engineer to the Syndicate. The letters and signs are manufactured complete in every respect, and mounted ready for erection, without added resistances, by the Edison and Swan United Electric Light Company (Limited) at their Ponders End works.

MACHINE TOOLS.—Messrs. Lotz, Abbott and Co., of High Holborn, inform us that they have been appointed sole selling agents for Great Britain, the Colonies, and also for the United States of America, for the sale of Pittler's Universal Lathe.

WRIGHT'S PATENT HEATER AND CONDENSER COMPANY.—This Company sends us an illustrated circular and price list of their feedwater heaters, condensers, and steam engines. They claim several advantages for their compound cylinder release engines.

WILLIAMS' HIGH-SPEED VALVELESS ENGINE.—It is claimed that this engine, which is being shown at the Laundry Exhibition, Islington, presents some remarkable features in economy, simplicity, and silent running. It has only three main working parts,



viz., the piston, crank-shaft with a curious oblique ball-and-socket crank, and crank-pin bearing; it has no valves, piston, or connecting rods, nor are the pistons packed. The pistons act as steam valves, and can be arranged to cut off steam at any part of the stroke. The engine, which is now being exhibited, gives 16 I.H.P. at 420 revolutions per minute.

ALTRINCHAM.—The contractors have commenced to lay mains for the proposed electric lighting of the town. The installation scheme includes the erection of plant at Broadheath, and the extension of the system to Rowdon and parts of Dunham Massey. The Manchester Edison-Swan Company has the contract.

AYR.—At the last meeting of the Town Council, Mr. Morton asked what was being done in connection with the electric light. He thought the policy of the Council was a dog-in-the-manger one; they were not doing anything themselves, nor allowing anyone else to do anything. Other members defended the delay, and it was pointed out that if the inhabitants said they would like the electric light the Council were prepared to take action immediately, but until they did so it would not be wise to move in the matter. At the same time, the idea of letting the Provisional Order pass out of the hands of the Council was deprecated.

BATH.—Complaints having been made as to the times at which the electric light is switched on and off, the surveyor has drawn up a table giving the exact time every day in the year at which the light should make its appearance and be extinguished. The table was explained at the last meeting of the Town Council, and after some discussion it was decided to turn the light on and off according to the table for three months.

BECKENHAM.—At the last meeting of the Local Board a letter was read from the Secretary of the Crystal Palace District Electric Supply Company (Limited), stating that the Company's mains had been laid in several thoroughfares within the Board's district, and

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asking whether the Board were prepared to entertain proposals for lighting these localities by electricity.

BRECHIN.—The Police Commission last week passed a resolution empowering the Watching and Lighting Committee to consider the question of the lighting of the new municipal buildings by electricity, and to report on the probable cost.

CAMBORNE.—The premises of Messrs. Holman Bros., iron-founders, are now lighted by electricity. Messrs. Veale and Co. (Limited) have laid down an installation consisting of 46 incandescent lamps and several arc lamps, ranging from 2,000 to 500 c.p. the current being generated by a Crompton dynamo. This is the first electric light installation in Camborne, and, with the exception of the Dolcoath mine, the first in the neighbourhood.

CAMBRIDGE.—The Guildhall and Building Committee of the Town Council reported at the last meeting of the Council that, in reply to their request for estimates for the installation of the electric light in a portion of the Guildhall, two estimates had been received from local firms, and they recommended the Council to accept that of Messrs. Medhurst (now Messrs. Russell and Co.) at £37. 5s., subject to a slight alteration in the lamps, which would entail an additional cost not exceeding £5. The adoption of the Committee's report having been proposed, Mr. F. Morley inquired the name of the second firm tendering and the price they tendered at ; but the Deputy-Mayor said that he did not think it was necessary to state the name of the firm, but the price asked was more than double. Mr. Morley said that if a good firm could not do work of this kind for less than £70 he did not think another firm could do it properly for £37. Mr. Bell having explained that the difference in the cost was owing to simpler arrangements being employed which gave the same results, the report was adopted.

CAPE TOWN.—The Government are negotiating with the Harbour Board with respect to the supply by the Board to the new Post and telegraph offices of the electric light from their station in the docks.

CHESTERFIELD.—The Town Clerk reported at the last meeting of the Town Council that, although he had sent 261 circulars to the inhabitants of the compulsory area referred to in Mr. Shoolbred's report, inviting particulars of the anticipated requirements of electrical energy, if such were provided by the Council for private lighting, only thirteen replies had been received.

CORK.—The new offices of the Lady's Well Brewery have been fitted up with the electric light by Mr. Percival. The installation includes 104 pendant lamps of 150 c.p. each in the main office, six 32-c.p. lamps over the principal desk, and 18 lamps are distributed over the ties of the roof, the general effect being very good. Mr. Percival has also fitted up telephones throughout the offices.

FALKIRK.—The Town Council have decided to oppose the application of the Caledonian Electric Supply Company (Limited) for a Provisional Order for supplying electricity in the Burgh.

GREAT YARMOUTH.—The Town Clerk stated, at the last meeting of the Town Council, that the Local Government Board, prior to sanctioning the loan required for the purpose of electric lighting, insisted that the site upon which it was proposed to erect the building should be vested in the Urban Authority. The Finance Committee, therefore, recommended the Council to grant to the Urban Authority, for the purpose of an electric light station, a piece of land on the east side of the Southgates-road. The recommendation was adopted.

HOVE.—The Local Government Board have given their sanction to the Commissioners borrowing £1,400 for the purpose of lighting the Town Hall by electricity, stipulating that the loan be repaid within a period of 10 years. It was moved that the question be dropped, but on a division it was lost. The appointment by the Electric Light Committee of Mr. E. F. J. Hewlett as electrical engineering assistant was confirmed by the Committee.

HUDDERSFIELD.—The Corporation's electric lighting scheme originally provided for the supply of current for the purpose of illumination to the central business part of the town ; but in consequence of numerous demands for the light for residences in the Edgerton district, mains for its supply are being laid. When completed the extension will cover a lineal measurement of about two miles, a considerable number of the large residential establishments receiving installation. The Technical School and the Borough Club are amongst the buildings in Bradford lately fitted up with the electric light.

LEWES.—The Works Committee of the Town Council have instructed the Town Clerk to make inquiries as to the cost of obtaining a Provisional Order for lighting the town by electricity.

MAIDSTONE.—Mr. Barker asked, at the last meeting of the Local Board, what had become of the electric light question ; it seemed to him to have dropped. The Town Clerk replied that a meeting of the Committee would be held very shortly ; it had been delayed owing to the absence of several members.

NEWPORT (MON.).—The Electric Lighting Committee have recommended the Town Council to appoint Mr. Robert Hammond as consulting electrical engineer, and that he be paid a commission of £5 per cent. on the cost of the installation (exclusive of land), to cover all the travelling and out-of-pocket expenses, and the service of a resident engineer to act as clerk of the works.

NEWTOWN (SHROPSHIRE).—A discussion arose at the last meeting of the Local Board on the question of lighting the town, and Capt. Pryce-Jones said a report had been received from some electricians on the subject of lighting the town by electricity, and, although they saw there would be many advantages, it could not be adopted at present, because it was probable that great strides would be made in the science, and electric light would most likely become much cheaper. After some discussion the subject dropped.

NORMANBY.—At the last meeting of the Local Board a member referred to the excessive cost of gas lighting, and moved that the Board should take into consideration the question of electric lighting. This was agreed to, a sub-committee being appointed to go into the matter.

PAIGNTON.—At the last meeting of the Local Board, a letter was read from Messrs. S. D. Williams and Co., of Newport (Mon.), asking if the Local Board were in a position to consider the question of lighting the district by electricity. If so, Messrs. Williams and Co. were prepared, in return for the concession, to provide and work the necessary plant. A letter was also read from the general manager of Messrs. Woodhouse and Rawson United (Limited), of the same tenor, and asking also if the Board were prepared to entertain a scheme for running electric launches for ferry-boats to and from Torquay. After some discussion, the letters were referred to a committee.

RYDE.—A letter was read at the last meeting of the Town Council from Mr. C. B. S. Lay, of the National Telephone Company, stating that a public meeting would shortly be held with a view of establishing a telephonic exchange between the various towns in the Isle of Wight.

SHOREDITCH.—The Electric Lighting Committee of the Vestry reported last Tuesday that they had considered the reference back to them of their report on the Pitfield-street site, with instructions to make a further financial statement and report. So far as the electric lighting scheme is concerned, the committee think that the report of Mr. Manville contains the fullest financial information that can be afforded until a site has been actually acquired. With regard, however, to the dust utilisation part of the scheme, and the amount of heat which would be available for baths and washhouses and motive power, they thought it would be advisable and very useful in a scheme of this magnitude to obtain a financial report from Messrs. Manlove, Alliott and Co. (Limited). The committee have accordingly instructed this Company to report what results they could guarantee with regard to the cost of burning 20,000 tons of dust per annum, and the amount of heat which would be available for baths and washhouses and electric lighting purposes, and the capital cost of maintenance. The charge for the report is not to exceed £10. 10s.

TAUNTON.—The Corporation announce that they will be prepared to supply electricity from their central station from October 1st.

WARMINSTER.—It had been suggested that the electric light should be supplied at the fountain ; but at the last meeting of the Local Board Mr. Chambers said it appeared that the probability of the fountain being so lighted was rather distant, and, as the winter was approaching, he suggested that a Sugg lamp should be placed there. Another member, however, said he had hopes the electric light matter would be arranged very shortly ; and it was agreed to leave the question in abeyance.

WESTON-SUPER-MARE.—At the last meeting of the Town Commissioners the Inspection Committee reported that they had been waited upon by a representative of the firm of Messrs. John Fowler and Co., Leeds (Limited), who said that his firm would be willing to prepare and submit a scheme and estimate for fitting up an electric lighting station and laying down plant within the compulsory area. The Committee, however, explained that, as the Board were in negotiation with the Brush Electrical Engineering Company, they could not give his firm any instructions at present.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment on October 13th next of interest of 3s. per share (less income-tax), being at the rate of 6 per cent. per annum, on the Preference shares of the Company for the quarter ending September 30th, and the usual interim dividend of 2s. 6d. per share on the Ordinary shares (free of income-tax) in respect of profits for the quarter ended June 30th. The register of transfers will be closed from October 6th to 13th, both days inclusive.

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NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1893, pages 320-348, *&c., &c.*]

CALVERT AND CO. (LIMITED).—This Company was registered on September 18th, with a capital of £2,000, in £1 shares, to acquire, take over as a going concern, and carry on the mechanical, electrical, and general engineering business carried on under the trade name of "Calvert and Co.," at Wandsworth, S.W. The first Directors are F. G. Hughes, J. R. Thame, and F. H. E. Shipton.

ELECTRO-PROTECTOR SYNDICATE (LIMITED).—This Company was registered on September 16th, with a capital of £10,000, in £1 shares, to acquire, develop, and turn to account certain patents, patent rights, inventions, licences, &c., particulars of which are not given, with a view to adopt and carry into effect an agreement made between Robert Jewell and Charles O. Greenwell (for the Company), and to carry on the business of electricians, mechanical and electrical engineers, suppliers of electricity, and manufacturers of and dealers in mechanical and electrical apparatus for registering the receipts of moneys. The subscribers (with one share each) are:—C. O. Greenwell, 63B, Elizabeth-street, Eaton-square, S.W.; E. G. Saunders, Nithwater House, Barnes, S.W.; C. E. Masterman, 6, Thorny Hedge-road, Gunnersbury; A. H. Portch, 38, Scylla-road, Peckham Rye, S.E.; T. E. Smith, 13, Clifton-crescent, Sutton; A. W. Letts, 59, Broad-street-avenue, E.C.; and R. R. Garratt, 59, Broad-street-avenue, E.C. The first Directors are Thomas Beard, A. H. Macnaughten, Edward S. Claremont, and H. E. Saunders.

JEREMIAH COWDY AND CO. (LIMITED).—This Company was registered on September 13th, with a capital of £10,000, in £1 shares, to purchase and carry on the business of iron and steel merchants, lamp manufacturers, iron and brass founders, wire drawers, &c., carried on by Jeremiah Cowdy and Co.

MARCHANT, YOUNG AND CO. (LIMITED).—This Company was registered on September 14th, with a capital of £4,000, in £1 shares, to carry on the business of electrical and mechanical engineers, and any business connected therewith. The subscribers (with one share each) are:—S. F. St. Steadman, 23, Old Broad-street, E.C.; J. E. Marchant, 166, Clerkenwell-road, E.C.; C. T. Young, 19, Woburn-place, Russell-square, W.C.; H. C. Campion, 23, Old Broad-street, E.C.; G. Groves, 48, Sarsfield-road, Balham; F. H. Robinson, 12, Percy-road, North Finchley; G. C. Hay, 126, Chesterton-road, Kensington. The first Directors are:—Bernard J. Young, John E. Marchant, and Charles T. Young. Registered with the Memorandum and Articles of Association of this Company was an agreement, dated September 13, 1893, made between John E. Marchant and Charles T. Young (called the vendors), and Cooper Corbidge (acting on behalf of the Company), and providing for the sale to the Company of the business of electrical and mechanical engineers carried on by the vendors at 166, Clerkenwell-road, London, for £1,780, payable by the allotment as fully paid of 624 shares to John E. Marchant, and of 1,156 shares to Charles T. Young. The vendors are appointed Managing Directors at a salary of at least £3 each per week.

ROTHERHAM FORGE AND ROLLING MILLS COMPANY (LIMITED).—This Company was registered on September 13th with a capital of £25,000, in £20 shares, to acquire, develop, and turn to account the business of manufacturers of steel and iron forgings and rollers of steel and iron, carried on under the same name.

SHILLINGFORD WORKS COMPANY (LIMITED).—This Company was registered on September 14th with a capital of £10,000, in £1 shares, to acquire, by purchase or otherwise, and carry on the business of mechanical and electrical engineers, millwrights, toolmakers, machinists, brass and iron founders, boiler makers, electricians, &c., carried on by the Shillingford Works Company.

WOLVERTON AND STONY STRATFORD DISTRICT NEW TRAMWAY COMPANY (LIMITED).—This Company was registered on September 15th with a capital of £5,000, in £100 shares, to acquire a tramway at present carried on at Wolverton and Stony Stratford, Bucks., and to work the same with steam, electrical, mechanical, animal, or other power.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—When the return of this Company was filed on August 28th, the whole nominal capital of £600,000, in shares of £10 each, had been taken up and paid for in full.

ECUADOR TELEPHONE COMPANY (LIMITED).—The annual return of this Company, made up to August 10, 1893, has been filed; 5,000 shares out of a nominal capital of £100,000, in £5 shares, have been subscribed for and allotted, and upon these shares the full amount has been called, and all calls have since been paid.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company made up to August 11th, has been filed. The nominal capital is £1,000,000, divided into 150,000 "A," and 50,000 "B" shares, of £5 each; 106,400 "A" and 23,564 "B" shares have been taken up; 82,261 "A" shares have been issued, with £3 per share considered as paid, and 17,139 "A" and 23,564 "B" shares have been issued as fully paid, representing a total amount of £426,667. 10s. Upon the 89,261 £3 paid "A" shares a call of 10s. per share has been made, resulting in the payment of £44,630. 10s., this being the working capital.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).—No changes have been made in the number of shares taken up in this concern since the last return was filed, 20,000 Ordinary and 100 Founders' shares being the number allotted. £1 per share has been called on the former and the full amount on the latter, the whole totalling £20,500.

ELECTRICAL POWER STORAGE COMPANY (LIMITED).—The annual return of this Company, made up to August 10th, shows that 70 Founders' and 18,657 Ordinary shares, each of the value of £5, have been taken up; 15,120 of the Ordinary shares were issued as fully paid, and a call of £3 per share has been made on the remaining 3,537 shares, while the full amount has been called on the 70 Founders' shares. The calls paid amount to £9,221. 18s. 9d., while £1,369. 1s. 3d. is still in arrears. In consequence of non-payment of calls, the holders of 200 Ordinary shares have forfeited the £2 per share previously paid on them.

EXCHANGE TELEGRAPH COMPANY (LIMITED).—The return of this Company for 1893, made up to August 16th, has been filed. The nominal capital is £246,250, divided into 8,125 "A" and 16,500 "B" shares of £10 each. All the "A" and 16,200 "B" shares have been subscribed for, the "B" shares being considered as fully paid. 2,125 "A" shares were issued, with £8 per share considered as paid. On these same shares a call of £1 per share has been made, and on the 6,000 "A" shares remaining £9 per share has been called, resulting in the payment of £56,023, leaving £102 in arrears.

MANCHESTER EDISON-SWAN COMPANY (LIMITED).—The annual return of this Company, made up to July 28th, has been filed. The nominal capital is £550,000, divided into 50,000 "A" shares of £9 each, and 10,000 "B" shares of £10 each. 20,000 "A" and 10,000 "B" have been taken up. £1 per share on the former has been called, while upon the latter the full amount has been called, the payments realising a total of £120,000.

MUNICIPAL ELECTRIC LIGHT AND POWER CORPORATION (LIMITED). The annual return of this Company for 1892, made up to December 31st, was recently filed. The nominal capital is £25,000, divided into 2,490 Ordinary shares of £10 each and 100 Founders' shares of £1 each. Thirty-seven Ordinary and 30 Founders' shares have been taken up, the full amount called, and £400 paid. The 1893 return, made up to July 13th, and filed with the foregoing, shows that no changes have been made.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended September 17th were £756, as against £744 for the corresponding period of last year, being an increase of £12. The total receipts for the half-year amount to £8,880, against £8,440 in the corresponding period of 1892, being an increase of £440.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).—The Directors of this Company on Wednesday declared an interim dividend, for the quarter ended June 30th last, of 2s. 6d. per share, free of income-tax, payable on the 14th prox. The Share Register will be closed from the 6th to the 13th prox., both days inclusive.

GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).—The Directors have declared an interim dividend of 3s. per share on the Preference and 1s. 6d. per share on the Ordinary capital.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—A second call of £2 per share on the Preference shares has been made, and is payable at the Bank of Liverpool (Limited) Water-street, Liverpool, on Monday, October 9th.

ROCKHAMPTON (QUEENSLAND) GAS AND COKE COMPANY (LIMITED). The report of the Directors for the half-year ended June 30, 1893, presented at the meeting held on August 11th contained the following:—Taking everything into consideration the Directors have reason to congratulate the shareholders upon the satisfactory results of the past half-year. With the gloomy and unprecedented state of financial matters characterising the past few months, and the consequent depression and insecurity in commercial affairs generally, the Directors had somewhat feared the Company would have felt the effects very much more seriously than it has done. The gas operations show a profit of £1,940. 14s. 9d. The electric light operations show an actual loss of £115. 15s. 5d., to which is added £289. 13s. 7d. interest upon the capital involved in the electric light plant and buildings, &c., making a debit balance in all of £414. 9s. The net profit for the whole of the Company's business is therefore £1,526. 5s. 9d. A great improvement appears in the electric light revenue as compared with that of the preceding half-year, while the working expenses are much reduced. The number of customers for the light is increasing, and public lighting with high-power arc lamps will be inaugurated on the Fitzroy Bridge in the course of a few months. In view of the large sum vested in the gas interests the Directors have thought it inadvisable to push the electric lighting operations, but have preferred to allow this portion of the Company's business to expand on its own merits and in response only to unsolicited applications for the light. The Directors anticipate being able to report an actual profit upon the electrical business at the next meeting of shareholders. The Directors recommend the payment of a dividend at the rate of 10 per cent. per annum, amounting to £1,724. 18s. 2d., which will necessitate the appropriation of £200 of the reserve fund for equalisation of dividends.

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WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended September 15, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £1,220.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED.)—The receipts of this Company for the two weeks ended September 15th were £1,840, as compared with £2,163 for the corresponding period of last year. The May receipts, estimated at £7,655, realised £7,608.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name	Previous Week's Price Sept. 13.	Price Wednesday, Sept. 20.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 20. Highest	Lowest
			TELEGRAPHS			£ s. d.			
£1,134,640	Stock	12 6	Anglo-American	50 51	50 51	5 7 10	Jan. Apr., July, Oct.	50⅝	..
£2,932,680	Stock	2/0	Do. Preferred	92¼ 9 ¼	92 93	5 18 3	" "	93½	92½
£2,932,680	Stock	5/0	Do. Deferred	9⅜ 10⅛	9½ 10	..	" "	10⅛	9⅛
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	99 102	99 102	3 18 5	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11½ 12	11½ 12	5 8 4	Mar., June, Oct., Dec.	12	11⅝
£36,400	£100	5%	Do. 5 per Cent. Bonds	99 103	99 103	4 17 1	January and July	100½	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107 111	107 111	4 10 1	June and December	..	..
£7,716,000	£100	7%	Commercial Cable Capital Stock xd	127 132	35 40	5 0 0	April and October	..	..
16,000	10	8/0	Cuba Submarine	11 12	11 12	6 13 4	February and August	11⅛	..
6,000	10	10%	Do. Preference 10 per Cent.	18 19	18 9	5 5 3	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid) xd	2½ 3½	2½ 3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent. xd	8½ 9½	8• 9½	5 5 3	" "	..	..
60,710	20	3/6	Direct United States	11½ 11¾	11⅝ 11⅞	5 18 2	Jan., Apr., July, Oct.	11⅞	11⅝
4 0,000	10	5/6	Eastern	15 15½	15 15½	4 5 3	" "	15½	15⅛
70,000	10	6%	Do. 6 per Cent. Preference	16 16½	16 6½	3 12 9	" "	..	..
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	111 114	111 114	3 10 2	May and November	114	112½
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	106 .09	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15½ 15⅝	15½ 15½	4 10 4	Jan., Apr., July, Oct.	15½	15⅜
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	110 113	110 113	3 10 10	February & August	110½	..
£70 600	100	5%	Do. 5 p. c.(Austln. Gov. Sub.) Debs 1900	102 105	102 105	4 5 3	January and July	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb.,1900	100 103	101 104	4 16 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	100 103	101 104	3 16 11	February & August	102½	101⅞
£200,000	£25	..	Do. 4% Mauritius Sub. Debs.	103⅞ 106⅞	103⅞ 106⅞	..	May and November	104½	104
180,227	10	4/0	Globe Telegraph and Trust	9⅝ 9¼	9⅝ 9½	4 11 8	Jan., Apr., July, Oct.	9⅝	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	15½ 15⅞	15½ 15½	3 17 5	" "	15⅝	15½
150,000	10	5/0	Great Northern	19½ 20½	20 20½	4 3 0	Jan., April, and July	20⅜	19⅛
£20),000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	103 106	103 06	4 14 4	March & September	..	..
17,000	25	37/6	Indo-European	39 42	39 42	5 19 1	May and November	40½	39½
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	3 6 8	" "	..	..
£100,000	100	6%	Do. 6 per Cent Debentures	104 107	105 108	5 11 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh.4% Guar. Debs. "Red" 1942	100 103	100 103	3 17 8	..	102	..
11,802	8	4/0	Reuter's	4½ 5½	4½ 5½	..	April and October	..	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6 per Cent.	115 120	115 120	5 0 0	" "	118½	117
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July	..	..
£260,900	100	5%	Do. 5 per Cent. Debentures	97 100	97 100	5 0 0	March & September	99½	..
3),000	10	2/0	West Coast of America	2 3	2 3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	97 101	97 101	7 18 5	June and December	100	..
88,321	10	6d.	West India and Panama	1⅜ 1⅝	1⅜ 1⅝	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 10⅝	10½ 10⅝	5 11 7	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	9⅝	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	106 109	106 109	4 11 9	June and December	..	..
64,242	15	4/6	Western and Brazilian	6½ 7	6½ 7	5 7 6	May and November	..	..
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5⅝ 6½	5⅝ 6½	..	..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1¼ 1⅝	1¼ 1⅝	..	..	..	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	..	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
£1,214,000	£1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	115 120	115 120	5 16 8	May and November	118	117½
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	101 104	101 104	5 15 5	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	2 3	2 3	..	..	..	..
224,850	10,0	3½d.	Consolidated Telephone Const. & Maintenance	1/16 1/8	1/16 1/8	..	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/8 1/8	1/8 1/8	7 18 2	Yearly	..	..
458,867	5	2/6	National	4⅜ 4⅝	4½ 4½	5 5 3	June and December	4⅜	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14½ 15½	14 15	4 0 0	" "	14⅛	14½
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14 15	13½ 14½	4 2 9	" "	18⅜	..
90,950	5	2/0	Do. 5% Non-Cumulative 3rd Pref.	5½ 5½	5⅜ 5⅝	4 13 0	..	5⅛	..
726 477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	111 113	112 114	3 18 11	January and July	113¼	112½
58,000	5	1/0	United River Plate	2 2½	2 2½	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	11½ 11⅝	11½ 11⅝	..	..	..	..
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½ 13	12½ 13	..	..	12⅛	12⅜
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	.. ..	.. ..	..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
8,322	£5	..	House to House Electric	.. ..	.. ..	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	.. ..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4½ 4½	4½ 4½	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6 6½	6 6½	..	..	..	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6½ 7	6½ 7¼	2 15 2	..	7	6½
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	104 107	104 107	4 13 6	June and December	106	106
6,452	£10	..	Notting Hill Electric	5 6	5 6	..	..	..	..
19,980	£5	9½%	St. James' and Pall Mall	6½ 7	6½ 6¾	..	..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	8⅜ 8½	8 8½	4 2 4	..	..	..
59,900	5	1/6	Westminster Electric Supply (fully paid)	4⅜ 5¼	4¾ 5¼	3 6 8	..	5	4⅜
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	2/1	Brush Electrical Engineering	2⅞ 3⅛	2⅞ 3⅛	..	..	3 1/16	2⅞
75,000	2	6%	Do. 6 per Cent. Preference	2⅞ 2⅞	2⅞ 2⅞	5 1 1	..	2 1/16	2⅞
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	106 108	106 108	4 3 4	March & September	107½	106
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	3½ 4½	3½ 4½	..	January and July	4⅜	4
12,189	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	1⅜ 2½	.. ..	..	..	..	..
49,900	10	12/0	Electric Construction	1½ 1⅝	1½ 1⅝	..	..	1 1/16	1
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜ ⅝	⅜ ⅝	..	..	½	⅜
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1 2	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22 3/16	22
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	103 105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	1 2	1 2	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/0 4/0	3/0 4/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	2 2½	2 2½	13 19 8	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	32 34	32 34	5 5 10	March and July	33¾	33
£150,000	100	5%	Do. 5 per Cent. Bonds, red.1894	101 104	101 104	4 16 2	January and July	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	¾%	City and South London Railway	35 37	35 37	1 13 9	May and November	..	..
37,500	£10	..	Liverpool Overhead Railway	5½ 5½	5½ 5½	..	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 802.—Vol. XXXI. FRIDAY, SEPTEMBER 29, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

The experiments on the transmission of signals, not through space but through sea-water, by Mr. Willoughby S. Smith in our present issue are certainly less magnificent than those of Mr. Preece, but owing to the uncertainty as to the nature of the latter no useful comparison can be made between them. The equipotential curves, shown in the present communication, would be precisely the same in an ocean of mercury. The fact that the currents which Mr. Willoughby S. Smith has employed may be detected at a greater distance, in a bad conductor like the earth than in a good conductor like sea-water, can be explained in quite a different fashion from that adopted by Mr. Preece; for in all his experiments the receiving instrument acted like a voltmeter; and as, for a given total leakage current through the earth, the voltages must be smaller in proportion to the conductivity of the soil, it follows that with bad conductors the potentials will be high, and the earth currents can be detected at greater distances than with good ones. The experiments by the late Mr. Willoughby Smith were described in *The Electrician*, Vol. XXI., pp. 492 and 832.

"I think you are rather down on the small wiring firms in last week's leader," writes a correspondent. "It is true these people require a rap on the knuckles occasionally, but these 'electrical micro-organisms' have a function in connection with the supply from central stations in getting business and lights. I wish we could set a few more of them to work." It was with no intention whatever to rap them on the knuckles that we called attention to these useful microbes. We made a passing reference to the rawness of some of them. "Everything must have a beginning," may be pleaded. True; every dentist must draw his first tooth from somebody's head, but the public have no means of distinguishing between these beginners and experienced firms, many of which make not only business but an art of wiring, especially in elaborate and well-decorated houses; such work demanding a great deal of ingenuity, principally because it is not carried out in conjunction with the architect. The high-class instruction in electrical engineering given by the technical colleges is useless here, and is thus often wasted. We would much rather see young plumbers, house-carpenters, and gas fitters receiving "technological" instruction on practical electric wiring, say, at Finsbury, at the evening classes, and thus enable tradesman to employ intelligent and competent hands, than see young men who have had a technical and perhaps a scientific training drifting, or pressed by over-crowding, into this useful trade. But we repeat it was hardly for this work that parents "put" their sons "into electric light."

The great expenditure of electrical energy in starting electric locomotives has been frequently alluded to in these columns. Part of this expenditure goes to the work of acceleration in starting the car or train, but a great deal of it is wasted. Force is wanted more than work, especially for the first few seconds, but force cannot be obtained without work; that is to say, the driver cannot get amperes without taking the volts. Mr. W. W. Beaumont's variable gear, which was described in *The Electrician*, Vol. XXX., p. 564, was designed to lessen their loss. At the British Association, in Section G, Mr. Beaumont described two modified arrangements of this gear. In one of these he has been able to abandon the electric clutch, very properly preferring a mechanical arrangement where possible. He has also avoided the use of wheels running idle at high speeds. A second design has been made for tramcars on which single reduction gear is employed. It seems a pity to use any permanent gear when Mr. Beaumont's ingenious mechanism itself provides so complete a range of gear. Gearless locomotives are in regular use in America, but the cars are run at higher speeds than would be tolerated in this country, and first cost seems to be no object. Two motors should be used if only to provide for the possible breakdown of one; and having two, Dr. J. Hopkinson's method of coupling them in series or in parallel provides in effect another range of gearing for hill climbing. We look forward, therefore, to the use of Mr. Beaumont's gear on otherwise gearless tramcars as well as on electric railways.

The pure waste of current in starting a motor, apart from the work of acceleration when it has to start with a load, is even greater with alternate currents than with continuous. Some so-called self-starting motors are almost useless on this account. We understand that the Oerlikon Company, who have brought multiphase motors to a practical form, no longer recommend the use of this system for supplying power and light from the same mains. They have found it impossible to adjust the load on the different circuits so as to avoid large variations of voltage at the starting of motors of even small power. In the recent trials by M. Turettini at the Geneva central station of a new 10 H.P.

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motor, the current at starting was 250 amperes at 110 volts, or equivalent, as far as the mains are concerned, to a draught of 37 H.P., for a very appreciable period. Judging from the state of the alternate-current motor business in this country it would seem that any further contribution to the mathematical discussion and theoretical design of such machines is for the present superfluous. But for simple cases of transmission of power, as well, perhaps, under certain conditions which are not yet very clear, of distribution of power, such motors are likely to be used elsewhere, and we therefore have no hesitation in printing an article from Herr EMIL KOLBEN, who during the past two years as chief engineer to the Oerlikon Company has had exceptional opportunities for designing and testing a large number of alternate-current motors. The article contains a great number of formulæ, some of which are rather complicated, but it is, nevertheless, a useful one, and keeps well to the point. There is no attempt to lengthen the argument by needless allusion to theoretical points, and some of the formulæ given are empirical, and contain numerical constants founded on experience alone.

IN the course of the discussion which followed the description of a ballistic galvanometer by Dr. OLIVER LODGE, at the British Association, Prof. FITZGERALD made a proposal of great interest in connection with the observation of very small motions of rotation. We have asked Prof. FITZGERALD to explain his idea more fully. He tells us that it is nothing more than a suggestion, but we are glad to be able to give it in his own words in another column. It seems probable that the displacement of interference bands, which has been employed by MICHELSON for measuring double star distances and the satellites of Jupiter, may be of great use in physical measurements on what Dr. STONEY has called the borderland of the visible. An interference method for measuring the diameter of small wires ought not to be difficult to contrive or to use.

THE interest which was evoked during the last session of the Institution of Electrical Engineers, by the Paper by Mr. W. B. SAYERS on his ingenious mode of producing an exciting field in dynamos without the use of field-magnet coils, was renewed at the British Association meeting at Nottingham. As this town is within half-an-hour's journey of Derby, at the Midland railway station of which town these novel dynamos are now in use, we have no doubt that many electrical B.A.'s made a pilgrimage for the purpose of examining them. We found these dynamos in one corner of the remarkably trim and pretty generating station belonging to the Midland Railway Company, where they are employed as regulators or balancing machines on the three-wire mains for lighting the railway station, offices, and yard. As it was high noon when we paid our visit, there was no difficulty in detaching the regulators from the circuit and subjecting them to a full-load test. It has been predicted by theorists that the notched method of winding the armature must give rise to considerable heating. We found, however, that after a considerable run with a current in the armature much above the normal, the armature was not warmed perceptibly; it was as cool as the bed-plate, and certainly cooler than the commutator or the bearings. The whole machine, in the case of each regulator, ran smoothly, and with little heating. The regulators are driven by motors on the lighting circuit.

IT is without surprise that we note that Dr. OETTEL'S claim to originality in the observation of the behaviour of an unconnected plate hanging between anode and cathode in an electrolytic cell, which we have already gently ridiculed, has been denied in all seriousness in the correspondence columns of the journal—the *Chemiker Zeitung*—in which his communication first appeared. The *advocatus diaboli* in this case is Herr A. VOIGT, and he quotes English authorities (GUTHRIE and BOYS, *Phil. Mag.*, 65, 4, 328, 1880) in support of his contention. Like ourselves, however, he pays a tribute to Dr. OETTEL'S careful presentation of the quantitative side of a well-known phenomenon.

THE note in our last issue on the use of high-frequency discharges by M. D'ARSONVAL and by Prof. D'ODIARDI has called forth a letter from the latter. The communication deals, however, with the medical side of the subject, and must therefore be excluded from our columns. We reminded our readers a twelvemonth ago that English medical men observe a self-imposed rule which forbids communication on medical subjects to non-medical journals and scientific societies, and we intend to respect this convention.

THE series of three articles by Prof. POYNTING, which we commence this week, were written in response to our request for a review of Dr. OLIVER LODGE'S second edition of his "Modern Views." In these articles Prof. POYNTING makes a critical examination of the hypothesis, or rather the hypotheses, of Dr. LODGE, but in perfectly plain language, and without going into any mathematics. It seems to us to be a matter of great importance that clear distinctions should be made between analogies, working hypotheses, and theories. In Dr. LODGE'S book it is difficult to find such distinctions, and the reader who is delighted with simple mechanical arrangements of cog-wheels, as analogies, is left in doubt as to whether any suggestion is intended that an atomic ether actually works in this way.

Cable Interruption:

	Date of Interruption.
Pernambuco-Ceara	September 1st.

Electric Traction on the Canadian Pacific Railway.—It is stated, says *Industries and Iron*, that the Canadian Pacific Railway Company will adopt electricity for drawing trains up a cañon known as Kicking Horse Pass.

Electric Traction in Madrid.—We understand that the Allgemeine Electricitäts Gesellschaft is connected with the new company which has been formed in Berlin, with a capital of 7,500,000fr., for the purpose of introducing electric traction into the tramway systems of Madrid.

Electrical Communication with Lighthouses and Lightships. A Bill has been introduced into the United States Senate directing that experiments shall be made to determine the most

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effective means of establishing and maintaining communication by telephone or other electrical apparatus between lightships and outlying lighthouses and the shore.

Search-Lights and Night Attacks.—An interesting and instructive night attack was made at Portsmouth last week. The primary object was to determine how far the electric lights of shore defences are efficient for lighting up vessels attempting to approach the harbour. As far as observation went, the electric lights appeared too feeble for the purpose contemplated.

Switzerland.—Two new lines of electric railways, recently constructed by the Compagnie de l'Industrie Électrique, of Geneva, are shortly to be opened to the public. The one of these is an extension from Veyrier to Monnetier, of the Salève mountain railway described in *The Electrician*, Vol. XXXI., p. 494. The other extends from Orbe to Chavornay, and is constructed to take ordinary goods trucks.

Popular Lectures.—At the Royal Victoria Hall, Waterloo Bridge-road, during October, Dr. Halliburton will lecture on "Electrical Fishes," and Prof. Reinold on "The Compass in Iron Ships." At the great Assembly Hall, Mile End Road six Gilchrist lectures will be given on alternate Thursdays, beginning September 28th. Prof. J. A. Fleming will lecture on "Magneto and Electric Currents" on October 26th.

Electric Tramway Return Leads.—The latest idea in electric traction is the method proposed by the late Lord Alfred Spencer Churchill. Instead of an uninsulated return, he proposed to employ a buried insulated conductor, and at every 20ft. or so to erect a special contact piece above the roadway. On the car there is to be a brush so long that it will always touch one of these contacts, and thus always be in communication with the main conductor.

Telephonic Communication on the East Coast.—The Post Office authorities have decided to lay a cable from the Gunfleet Lighthouse to the Old Gapway, at Frinton, near Walton-on-the-Naze, as the first portion of the telephonic communication between the various lighthouses and vessels and the coastguard stations at Harwich, Walton, and Clacton, all three of which will be connected by a land wire. The operation of laying the cable is now in progress.

Lausanne.—We are informed that very extensive system of electric power distribution has been submitted to the Town Council of Lausanne. It is proposed at first to take about 1,200 H.P. from the River la Grand Eau, near Aigle, at 40 kilometres from Lausanne. This would be used for supplying about 5,000 16-c.p. glowlamps during the hours of darkness, and in daylight the power would serve to pump water from the lake to supply the town. The surplus energy would be devoted to driving motors for tramcars, and in shops and factories.

Telephoning in the Navy.—Telephonic communication has been established between the "Lion," training ship, and the Royal Naval Barracks, Keyham. With the exception of the "Impregnable" training ship, the whole of the depots at Devonport are connected by telephone. A party of men from the torpedo school, "Defiance," have carried out the work, under the direction of Mr. Brockman, torpedo gunner. The "Impregnable" will be included in the system as soon as arrangements can be made for moving her head and stern, and thus prevent her swinging with the tide.

Manchester.—On Saturday last the lamps already connected to the mains of the Manchester electric light supply, which have up to the present been used as a simple two-wire system, were disconnected prior to the rearrangement of the mains upon the five-wire system. The lamps were subsequently placed on the various sections of the five-wire 400-volt system with success, and will continue to be run on that system. The number of lamps disconnected from the old system exceeded 10,000; but so great is the demand for electric light that it is expected to be able to have 30,000 lamps on the new system before very long.

Electric Lighting Concessions in France.—The Cahors Gas Company recently asked the municipality to grant it an electric lighting concession, and offered to supply current for public purposes at 1s. 4d. the kilowatt hour, and for private purposes at 1s. 6d. the kilowatt hour. These prices were too high for the municipality, and a committee was appointed to inquire into the prices charged elsewhere in France, and found that the average price charged at St. Etienne, Nimes, Havre, Vannes, Paris (Sector Drouot), and Bayonne, came out at about 10d. per kilowatt hour. The Gas Company has now had the following private lighting tariff submitted to it by the municipality:—10d. per kilowatt hour consumed by each 16-c.p. lamp alight from 60 to 100 hours per month, with reduced charges in the case of lamps burning a longer time each month.

Edison-Bell Phonograph Corporation.—This Company seems to be rather hurt by our remark last week that phonographs, after many years of obscurity, are appearing among street shows, and invite us to inspect the instrument which they are now offering. We wrote from actual observation at the last St. Giles's Fair at Oxford, and in Farringdon-road, and elsewhere. The public, no doubt, get an excellent pennyworth, for the last phonograph which we tried, at a garden party, left nothing to be desired; it is a distinctly better toy than a musical box. Its commercial value can only be measured by its commercial success. We learn that a rental of £10 per annum, with a rebate for additional instruments, is asked, and postal cylinders in cases cost 9d. each. When we hear that 500 instruments are in use in London, or 1,000 in the United Kingdom, for commercial purposes other than street shows, &c., it will be time to consider whether a commercial success is probable.

Brighton Arc Lighting.—Councillor Ballard has been critically inspecting the electric lighting of the Brighton Front, and, as a result, has sent a budget of suggestions to the Lighting Committee. He says:—

I beg to call your attention to the following defects in the electric lighting on the Sea Front at Brighton. 1st, to the inordinate height of the lamps; 2nd, to the waste of light caused by the ornamental supporters of the canopy over the lamps; 3rd, to the uselessness of the canopies over the lamps for the purpose of reflectors. I beg to suggest as follows:—1st, that the lamps should be lowered to about the height where the ornamental part of the lamp-post ends and the fluted part begins. I have compared this with the electric lamps outside the tobacconist's at the Pier, and find that the lamps would then be higher than those at the tobacconist's. 2nd, that the canopies should be upheld by a single piece of iron on the south side, and the present ornamental supports be removed. 3rd, that the present canopies be removed and replaced by a more flattened shape, and a highly reflective enamelled inside surface. The above, although of importance with a view to obtaining the highest degree of illumination, are matters of detail; but in other respects I have to congratulate the Committee on an installation far more liberal than I ever expected, and uperior to anything I have ever seen in Paris or London.

The Glasgow and Belfast Telephone System.—Some four months ago, at a cost of about £20,000, the Post Office laid down a telephone between Glasgow and Belfast. The tariff, however, says a Belfast paper, was so prohibitive, namely, 5s. for three minutes' conversation, that for over two months no business followed. The price was then reduced to 3s., or 1s. a minute, and since this reduction, which took place on the 20th July, there have been six conversations across the wire. One of these extended to nine minutes, thus costing the caller-up 9s. By an arrangement just entered into with the National Telephone Company, there are to be increased facilities for telephonic communication between the two commercial capitals which should lead to extended business. Subscribers can now, if they so desire, get switched on to Belfast from their places of business. As, however, the line to Belfast is on the metallic circuit system, subscribers will require, at trifling addition to their rental, to have their wires on the same principle, so as to ensure good communication.

University College, London.—We have received the syllabus of this College, and are informed that the new engineering and electrical laboratories will be opened for work on October 3rd. "It should be clearly understood," says the syllabus of the Applied Science and Technology Department, "that the education given in this department of the College is not intended to supersede such necessary practical training as can only properly be acquired in the workshop or factory." This warning is repeated more than once, nor is it contradicted by offering workshop instruction as part of the ordinary course. "Students taking a three-year course, and in special cases others, may be

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permitted, at the discretion of the professor, to work in the laboratory workshop under his direction, making models of apparatus, &c., described and illustrated in their lectures. Any student desiring this privilege must make special application to the professor." Distinct from this workshop, there are the new engineering and electro-technical laboratories, in which we have no doubt much valuable practical work will be done.

The Comparative Cost of Gas and of Electricity.—At the Urban Town Hospital, Berlin, the electric light is in use; the current being generated on the premises, and 1,220 glow and 30 arc lamps being fitted. During the year 1891-2 there were used 1,025,800 ampere hours, and their cost was £1,416. The average cost per glow lamp per hour was 0·1572d. for current and 0·0324d. for renewals, the lamps lasting 600 hours. The average cost per arc lamp was 1·156d. per hour for the current, and 0·252d. for carbons. The prime cost for machines and apparatus was £5,052, and for wiring, &c., £3,124. Taking sinking fund and depreciation, on the former at 12 per cent. and on the latter at 8 per cent., these items would make a total for the year of £856, and taking this into account the hourly cost of the glow lamp would come to 0·2916d., and that of the arc lamp to 2·16d.; while the total annual cost would be £2,272. With gas at 4s. 3·886d. per thousand, the annual cost would have been £2,471. If the current had been taken from the central station, the total annual cost would have been £3,583.

The West End Street Railway of Boston.—The resignation of Mr. H. M. Whitney of the presidency of the West End Street Railway Company is announced. Soon after the consolidation of the Boston lines some years ago, Mr. Whitney undertook the investigation of the various kinds of mechanical traction. Disappointed with the results of careful trials of a storage battery system, and realising the difficulties that the cable would be compelled to contend with in such narrow and tortuous streets, Mr. Whitney was induced to visit Richmond, Va., early in 1888, and witness the operation of the Sprague system. From what he saw at that time he was thoroughly convinced that the only practicable system of mechanical traction for Boston was the overhead electric system, supplemented possibly by a conduit system in the more crowded business streets. He returned to Boston determined to advocate its introduction, and the result of his efforts is well known. The conduit was tried and abandoned, being replaced by the trolly system throughout. Mr. Whitney is to devote his time hereafter to other than street railway interests.

Heavy Gradients Compensator.—One of the most ingenious contrivances for assisting tramcars up and down a short length of stiff gradient is described in the *Engineering Review* for September. The plant has been in successful operation for some time at Seattle, in Washington, U.S.A. For a distance of 1,000ft. there is a gradient varying from 11 to 16 per cent. Two counterbalance weights, aggregating six tons, run on rails laid in a conduit beneath the track. These weights exactly balance an empty car, and are attached to wire ropes running over pulleys. At the top of the gradient, on its way down, the car picks up the rope and, in descending, hauls the weights up, thus checking its own speed, so that the car brakes will hold the load without difficulty. At the foot of the gradient the conductor disengages the rope by means of a hand-lever. Going up, the connection is made automatically, and disengaged in a similar manner. A gradient of 20 per cent. may be readily overcome by means of this simple and admirable expedient. It will be evident that since the action is cyclical the only loss of power is that due to the small friction of the gear and tackle, while the only condition necessary to continuous working is that cars going up the gradient shall alternate with those coming down. In a horse-traction system such a device means humanity; in a system of electric traction it means smaller motors per ton of rolling stock, and a greater annual saving of energy, which would otherwise be spent in raising cars up hill, or in brake-power on the down trip.

The Electric Railway Boom in America.—We have had our own electrical booms in 1882-83 and 1890-91, and their origin is not unknown. Apparently the electric traction boom across the Atlantic has had a somewhat similar basis. According to the *Engineering and Mining Journal* of New York, "A local company is organised to build an electric street railway, say, by the efforts of the manufacturing electric company, which takes all the bonds of the local company, perhaps, or a part of them at least, in payment for the plant furnished. The central company holds these bonds until the local company becomes a going concern, and a favourable opportunity to dispose of them appears, when the transaction is closed. This system of business was made necessary by the very magnitude of the undertakings, especially when such electric installations were a new thing and the identification of the company which wanted to sell them with the local companies or purchasers was in the nature of a guarantee. It was for the interest of the manufacturing companies to follow this policy in order to sell the largest possible number of plants, not only for the profit in the first transaction, but also for the business of furnishing supplies to them ever afterward. The success of the Thomson-Houston and Edison electric companies, now consolidated as the General Electric Company, in building up an enormous business demonstrated the wisdom of this plan, but when the credit system failed, of course the whole fabric tottered, it being impossible to carry the bonds and securities of subsidiary concerns, and no capital coming forward for investment in new undertakings." If electric traction is to be developed in this country by these methods only discredit to the electrical industry will ensue.

Obituary.—We regret to announce the death of Mr. *H.* Weaver, which occurred at Folkestone on Wednesday, September 20th, from heart disease. Born at Shrewsbury on May 5, 1825, Mr. Weaver entered the Electric Telegraph Company in May, 1846, and had charge of various stations in England till 1853. In connection with this Company two submarine telegraph cables were laid between Lowestoft and the Hague, and subsequently two more between Lowestoft and Zand Voort, Holland. This undertaking was managed by Mr. Weaver until 1859, when the Dutch ends of the cables were transferred to the Dutch Government. Upon his return to London, in 1859, he became metropolitan superintendent for the Electric Telegraph Company, and manager of the International Telegraph Company in London, which position he occupied till 1864, when he was appointed secretary to the Electric and International Telegraph Company, and held that position till 1870, when the telegraphs were transferred by purchase to the Postmaster-General, under Acts of Parliament, 1868, 1869, and 1870. The whole of the negotiations for the purchase by the State of the lines, cables and business of the companies represented by him were under his control, he being appointed sole arbitrator. After the transfer of the inland telegraphs to the State, Mr. Weaver took the management of the Anglo-American Telegraph and the Atlantic Telegraph Companies, which position he has held since the January 1, 1870. In addition to being managing director of the Anglo-American Company, he was also director of the Indo-European Telegraph Company, director of the West India and Panama Telegraph Company, and the Western Union Telegraph Company, New York. Mr. Weaver originated the "word" system of counting and charging messages, and introduced it on the Atlantic cables on May 1, 1872. A funeral service was celebrated on Tuesday last, at St. Mary's, Bryanston-square, which was attended by a large number of friends, and the interment afterwards took place in Norwood Cemetery. ——Mr. Thomas Hawksley, one of the oldest members of the Institution of Civil Engineers, died at the age of 86 on Saturday last. Mr. Hawksley's earlier practice lay chiefly in waterworks and gasworks. He was President of the Institution of Civil Engineers for two years, in 1871-2; President of the Institution of Mechanical Engineers in 1876; and was one of the founders and the first President of the Gas Institute. He was elected into the Royal Society in 1878.——We have also to announce the death of Lord Alfred Spencer Churchill, which took place at his London residence last Thursday week, September 21st. He had been ailing for some time, and died at the age of 69 years. He was a great-uncle of the Duke of Marlborough, and, like him, much interested in electrical science. One of his latest inventions, a closed-conduit system of electric traction, is described in another note.

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AN EXAMINATION OF PROF. LODGE'S ELECTRO-MAGNETIC HYPOTHESIS.

BY PROF. J. H. POYNTING.

The leaders in Physical Science, impressed perhaps with the responsibility of their position, and fearing that their weaker followers will distort their views, are, as a rule, very cautious in giving us their vaguer speculations as distinguished from the more exact hypotheses which can at once be put into working shape. Yet these less formed speculations are often helpful, even if they only arouse our minds to attempt to disprove them. Still more are they helpful if they aid us in thinking of facts in a more connected way until the finished working hypothesis is ready to take their place.

We owe a special debt of gratitude on this ground to Dr. Lodge for his well-known book on the "Modern Views of Electricity," in which he describes not only the more definite beliefs which he firmly holds, but gives us also any suggestions rising in his mind which seem to give promise of light to guide us in the dark ways of the science. He talks as it were confidentially to us, and though the speculative character of the book makes it by no means the easy reading which the absence of mathematical treatment might lead us to expect, and even perhaps unfits it for beginners, the bold attempts at explanation give it great value to more advanced students. Such students will be brought face to face with many difficulties which they may hitherto not have recognised through haziness of thought. And even where they are unconvinced by Dr. Lodge's attempts to solve the difficulties they will be gainers by the orderly review of their knowledge necessary before they can form a judgment.

The book is built round a central hypothesis of the nature of electric action, which I propose to examine. I shall first give an account of the hypothesis as it appears to me to stand, freed from the details and the wealth of illustration, which, though appropriate, and even necessary, in the original work, make the argument at times rather difficult to follow. I shall then examine the evidence for or against the hypothesis.

We start with that which everyone accepts as the result of experiment and observation, that there are two kinds of electrification with oppositely-directed qualities, and that they make their appearance always in equal amounts. Hence, on their union, the net electrification is zero. Compare this with the case of momentum. According to our experience, as summed up in the third law of motion, we may regard the mutual stress between two bodies as consisting of a *transfer* of momentum from one to the other. A gun at rest is fired. The momentum gained by the bullet and powder may conveniently be regarded as derived from the gun, which, having none to begin with, now has an amount of negative momentum equal to the positive possessed by the charge. In other words, positive momentum is transferred from gun to charge. Or compare with a case of material transfer, as when A lends B a sum of money. Then A and B, after the transfer, are oppositely affected, so that if they both assign their share in the transaction to a third person C the effect on C is zero; or if B re-transfers the sum borrowed to A the net result is zero.

Such cases as these suggest that positive and negative electrification are merely the creditor and debtor sides of a single transaction, the sending out and the reception of something transferred (p. 9). What kind of transfer we must imagine is best gathered from the "ice-pail" experiment, a particular case of the general principle that when induction occurs + and − always *face* each other in equal quantities with an insulating medium between. We may suppose that we have a nearly closed hollow insulated conductor, and that through an orifice we introduce a body having on it a charge +Q. Immediately −Q gathers opposite to it on the inside surface, and +Q is on the outside surface, facing −Q on the walls of the room in which the experiment is made. If, instead of carrying out this electrical experiment, we imagine an indefinitely extended incompressible liquid, and think of merely mathematical surfaces occupying the positions of the surfaces of the conductors, the introduction of Q of liquid within the inner surface would force Q of liquid through each of the two surfaces, and relative to the space between the surfaces, inwards towards the inner surface, and outwards from the outer.

Now, suppose that such an incompressible liquid, to which for the present we need not ascribe gravitation, has an actual existence, that it fills all space with which we are concerned, and that it permeates matter, Let us suppose that in bodies which we term electrical conductors it is free to flow with nothing worse than frictional loss of energy, but that in insulators it has some kind of attachment to the matter, so that in the displacement of one relative to the other—that is, in the strain—energy is stored, and in such a way that it can be regained when the strain is relaxed. We shall call this liquid Electricity. When a displacement occurs, so that some of the liquid is pushed into or out of any conductor, the quantity flowing through the surface from or to the insulator is that which we have hitherto called the charge of electricity on the surface. We must now term it Electrification to distinguish it from the general body of the liquid, which is, according to Lodge, all Electricity. It is important to notice this distinction in studying Lodge's hypothesis. Electricity is the generic name for the fluid all through space, electrification the specific name for that part of it which happens to have flowed in any given disturbance through the surface of a conductor. Thus, if we imagine a conducting sphere A within a hollow conducting sphere B, B having an orifice through whichwe can introduce a wire to charge the inner sphere, say, positively, the gathering of a charge Q on A, is to be regarded as a flowing of some of the all-extensive electricity along the wire into the sphere, which is, however, already full of electricity. Hence Q must be pushed through the surface of the sphere out into the insulator or dielectric. This outward displacement manifests itself as the + electrification of A. As the dielectric is also initially full of electricity Q must be pushed out through every surface in it completely enclosing A. The displacement relative to the air particles stores energy—the energy of the charge. When we come to the inner surface of B, Q is pushed into the substance of B, an inward displacement which we term a negative charge. It is also pushed through the substance of B, but as this substance is conducting, no energy is stored, and only a little is dissipated by the frictional rub, or, perhaps better, the viscous cling. At the outer surface of B there is another displacement of Q outwards into the dielectric—*i.e.*, another positive charge, and energy storing begins again. The pushing out will take place through the second dielectric till we come to the walls of the room in which the action is occurring. Here it will probably end, for the generator of the original charge has probably sucked in the fluid from the walls. There is therefore a confined circulation, and not an infinitely extended pushing out.

Sources of electrification with their connecting wires are evidently to be regarded as turbines working in pipes or channels laid in space, incompressible and fluid electricity filling both the pipes and the space outside them. When the turbines work the fluid runs along the pipes, forming what we call an electric current. When a pipe ends in a reservoir bounded by a dielectric, the fluid presses out into the dielectric, and there stores the energy put into it by the turbine, *minus* that dissipated by the viscous resistance in the pipes and conducting channels.

Prof. Lodge illustrates the connection between the electric incompressible fluid (why not the electric liquid?) and the molecules of matter by a series of ingenious and suggestive models either with cord running through beads or with liquid to represent the electricity. It is hardly necessary here to describe these. Any reader who is not yet acquainted with them should study the original account. It is enough to say that Prof. Lodge can make his models behave like Leyden jars and give the phenomena of charge, residual charge, and oscillating discharge as perfectly as if they were thorough believers in his hypothesis.

I find it somewhat easier to form a picture of the hypothesis by supposing matter to have a sponge-like constitution, *i.e.*, to be permeated in every direction by passages, the pores so dear at one time to the writers on elementary science. These passages

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are filled with liquid electricity. In every passage or tube, however short, we must imagine a little turbine turning round with the flow through it and never letting any fluid pass without duly turning. In dielectrics there is a spring like the main spring of a watch, attached to the spindle of each turbine so that when the wheel turns energy is stored. In conductors this spring is wanting, and there is only a viscous resistance to rotation. We may think of the source of electrification, machine battery or induction coil, as a large turbine somewhere in the system with a supply of energy behind it dealt out by a motor of some kind or other. When the large turbine works a flow takes place in the system dissipating energy in the conductors and storing it in the dielectrics. When the charging turbine is removed or disconnected from the motor, so that the way is clear for a return, all the wound-up mainsprings return and drive the liquid back through the sponge. We have only to make the turbines with different moments of inertia, with different qualities of lubricator in the conductors, and with different strengths of spring, and different firmness of attachment in the dielectrics, to get varying permeability, electric resistance, specific inductive capacity, and residual charge. We may, perhaps, simplify the arrangement of affairs by supposing that the molecules themselves are the turbines, and then we get a kind of inversion of the hypothesis described hereafter, which Dr. Lodge develops to account for electromagnetism.

In the displacement hypothesis, with a single electric liquid flowing past matter, there is a very serious difficulty. The energy being stored by the flow past the molecules of matter, we might reasonably expect the electricity to pull, or to tend to pull, the molecules with it, and there should, therefore, be a motion of matter along the lines of force in one direction. But instead of this we have a tension, both ways as it were, along the lines of force or flow. There is displacement of matter only in the case of electrolytes, and here it is both ways along the lines of flow, one set of atoms going one way and another set the opposite way. A modification of the hypothesis is suggested by Dr. Lodge to meet this difficulty and to account for the double electrolytic procession. He supposes that there are two constituents of the electric fluid each in general filling half any space, intimately mixed and evenly distributed. The molecules of matter are made up each of two constituents in accordance with the usual view, and one of these is attached to one kind of electric fluid the other to the other. When electric displacement occurs it is really a double flow, the two constituents of the fluid travelling equal distances in opposite directions past each other. The atomic constituents of each molecule move in opposite directions, but not in general very far, so that there is in dielectrics no displacement of the matter as a whole. In electrolytes the displacement continues till separation and repairing occurs, and thus we get a double procession.

We see that in dielectrics the pulls of the two constituents of electricity in the molecules, one on one atom, the other on the other, balance each other. These electric pulls lead to internal stresses within the molecule about which Dr. Lodge does not say anything very definite, but it seems to me that we have to introduce chemical forces here to account for the pull of the atoms on each other, distinct from the electric forces or the pulls of electricity on matter. This dualism is hardly in accordance with the later exposition of Dr. Lodge's ideas, where he appears to identify electrical and chemical forces (p. 84). Perhaps we might as well, while we are inventing a constitution for the ether, make a third or neutral constituent to which all the atoms of matter are attached. We will suppose this neutral electricity to resist extension and compression. We then have electro-positive atoms attached to positive electricity, electro-negative atoms to negative electricity, and all of them to neutral electricity. When an electric displacement occurs, positive ether tugs at one set of atoms, negative ether at the other set, and neutral ether prevents their separation, so that all our forces are of one kind, insomuch as they are forces between atoms and ether. I rather like this neutral ether, but I am afraid Dr. Lodge will not adopt a strange infant into a family already sufficiently large.

But taking the hypothesis as set forth by its author, the mere duality does not much affect the general notion of the nature of electric charge. We must remember that motion of negative fluid inwards equally with that of positive charge outwards gives a positive electrification, so that the explanation of the electrification of a sphere within a conductor already given has only to be amplified by supposing that there is another ethereal fluid displaced in the opposite direction at the same time and throughout the system.

I can imagine the agnostic in ethereal matters protesting here against the multiplication of unknowns and unknowables. I can imagine him saying that his sense organs are only excited by material motions and affections, that his instruments are all material, and only appear to undergo changes of shape, colour, sound—*i.e.*, affections of matter and that he cannot with any certainty get beyond these material affections. He will argue that, as we have no sense affected by ether alone, we can form no adequate conception of the ether; we can only suppose it endowed with material properties, and conceive of it as some form of matter. And it would appear possible to imagine various material ethereal constitutions or connecting machineries between the different portions of matter evident to our senses, all equally accounting for all known facts. When a new fact turned up he would own that probably some of the ethereal machinery would fail to account for it, and so would have to be taken off to the lumber-room for worn-out hypotheses; but the new fact, he would argue, would very likely enable us to imagine new types of machinery to replace some, at least, of the old rejected ones. And probably, till the whole range of physical phenomena was known, it would always be possible to imagine more than one kind of machinery to account for the phenomena known. Probably only when nothing remained to be discovered would there be a single solution, and only then would it be possible to give a single answer to the question, What is ether? And even then we might be wrong, for the ether might have properties in its action on matter quite different from any of which we have material types.

Though our agnostic, when following this train of thought, may be unconvinced by Dr. Lodge's preface, and may urge that the ether is and will probably remain a hypothetical medium, he will, no doubt, adopt some form of hypothesis for working purposes. If he is an ordinary human being, when he studies such actions, as we term actions at a distance, he will prefer to think of the different parts of the acting matter as connected by something continuous, with material properties. Following Boscovich and Faraday, he may extend the atoms throughout space, and give this extension material properties (a special case of this type of hypothesis is presented to us in the ring vortex theory of the Universe); or he may limit the atoms and put in some new connecting machinery to fill up the vacuum he abhors, and this he may as well call "ether." While, therefore, he may protest against Dr. Lodge's "cocksureness" about any particular constitution for the ether, he is bound to examine any hypothesis reasonably presented to see if it is likely to form a good working hypothesis to account provisionally for the observed facts. He would, no doubt, admit that Dr. Lodge's hypothesis is reasonably presented, and it would only be a question with him whether so complicated a constitution for the ether enables him to think sufficiently easily of the phenomena for which it is to account. Leaving him to consider this, we may pass on to the further development of the hypothesis.

So far, we have only been thinking of the properties of electricity at rest. It is true that we have thought of the electricity as being pumped along conductors and as wasting energy in the passage; but this was only a step onwards to a final statical distribution. We are now to concentrate our attention on the pumping stage.

When electricity is in motion in sufficient quantity and for sufficient time, a new set of phenomena come into prominence. Among these are the heating of the conductor, the heating or cooling of junctions, the opposite ionic processions in electrolytes, and the creation of a magnetic field. The heating of the conductor is to be explained, according to Dr. Lodge, as something analogous to frictional, or rather viscous, dissipation

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of energy. We may think of the two streams of electricity flowing past the atoms of matter, and continually catching hold of them and letting them go again, as a fiddle bow catches hold of and lets go a fiddle string. Thus, some of the energy of flow is converted into vibrational energy of the atoms, that is into heat. The junctional heat phenomena still wait for complete explanation. We may consider that the facts imply that at a junction of dissimilar metals there is a tendency for positive electricity to move more easily in one direction than the other, and, of course, the reverse with negative electricity. A compound bar with free ends will thus tend to be positively electrified at one end and negatively at the other. Suppose, further, that the tendency to separation of electricities varies with the temperature, and we have at once the thermoelectric current in a closed circuit. Returning to the fiddle bow and string used to illustrate the development of heat by conduction, we can see how it ought to work to illustrate thermo-electricity. Suppose a set of parallel strings in a horizontal plane, one half tuned to one note and the other half to another. The one set may represent one metal with its atoms vibrating in given modes, and the other set another metal in contact with it and with its atoms vibrating in other given modes. Now, laying the fiddle bow across the strings after they are set in vibration, if the motion of the bow is always in one direction it illustrates the pushing of one of the electricities from one metal to the other. I have found that when light bits of paper are laid across two vibrating strings of different pitch there is frequently a movement of translation. Unfortunately for the illustration it is sometimes in one direction, sometimes in the other. The paper was not part of Prof. Lodge's book, and knew nothing of the hypothesis it was expected to support. The opposite procession of ions we may think of as the transport of the atoms by the positive and negative electric streams respectively, the connections between the pairs of atoms being broken down and renewed with fresh partners all along the line and continually.

(To be continued.)

THE ELECTRICAL CONGRESS OF CHICAGO.

BY PROF. SILVANUS P. THOMPSON.

One who sits down to review the proceedings of the Chicago Congress of 1893, and to draw an estimate of the work it may have accomplished for the advancement of electrical interests, finds himself involuntarily framing comparisons with the Congresses that have preceded it. Yet if he would rightly estimate its operations at their value, he must at least attempt to dissociate himself from such comparisons. For, in fact, each Congress is individual, not in reality bound by the decisions of any that have preceded it, and possessing no power to bind its successors. Each Congress has possessed distinctive features of its own, and that of Chicago now just closed is no exception. The location, the attendant circumstances, and the internal arrangements, all differed from those of previous Congresses. To begin with, it was the first and only International Electrical Congress held on American soil. Electrical Congresses and Conventions of purely local or only national scope have been held from time to time in recent years in the United States and in Canada. But at such gatherings the presence of a foreigner has been an unusual circumstance, and comparatively little importance has attached itself to any discussion or decision made. In the present case not only were many Europeans present, but the number of electricians from America itself exceeded that at any of the preceding gatherings in the States. And the Congress itself received an indefinable sense of importance to Americans from the circumstance that its decisions would in some way bind and commit the American nation on certain questions hitherto open. The situation in the States of such matters as the decision of a Congress might affect is somewhat as follows: In the International Congress held in Paris in 1881 and 1884 America was represented. Her representatives in the former year accepted the main decision then arrived at to adopt for international purposes the British Association system of units as modified by the addition of the names of the *coulomb* and the *ampere*, and with the substitution of the mercurial column for the old B. A. unit as the standard of resistance. But in 1884 when it was agreed to accept for the length of the mercurial column representing the ohm, the figure of 106cm., the American representatives had been amongst the dissentients, holding that a nearer approximation to the true ohm would be made by an addition of two or three millimetres. How completely they were justified subsequent events proved. But from that day to the present the so-called legal ohm (with the corresponding volt and farad) had never been recognised by the United States Government, which had taken no steps to legalise any electrical units or standards. This is the more remarkable when it is remembered that last year the United States adopted as the legal standards of length and mass, in America the actual *metre des archives* and the *kilogramme* now deposited at Paris at the International Bureau of Weights and Measures. Beyond question the leading electricians of America were prepared to act in concert with European nations. They had watched approvingly how at Frankfort the ohm of 106·3 centimetres was preferred to the legal ohm of 106. They had cognisance of the careful and anxious examination made by the British Board of Trade. They knew how at Edinburgh, in 1892, at the suggestion of Von Helmholtz, the definition of the ohm had been modified so as to express the standard column of mercury in terms of mass instead of those of cross-section. All this facilitated decision, and rendered concerted action more easy. There being no governmental telegraphs in the States, no official interference could prejudice the decisions of the Congress or balk the electricians of America from accepting them. Beside the main question of securing international agreement on the fundamental units and standards, there were a few other topics of American interest. There was the proposal to christen the unit of self-induction as the *henry* in honour of Joseph Henry, its discoverer. There was a suggestion to advise on legislation as to the proper way of describing the candle-power of an electric lamp. There were proposals to name a set of magnetic standards; to settle an international notation of electrical quantities; and to decide on a practical unit or standard of light. Such was the official programme before the Congress, but the unofficial programme was a much wider one. A very extensive list of suitable topics had been circulated many months beforehand, and Papers invited from numerous leading electricians. Keen debates were expected upon the burning topics of the day, and several of the Papers promised were avowedly written to promote discussion. Like the Congresses of 1881 and 1884, but unlike those of 1889 and 1891, which were of an unofficial character, the Congress of 1893 comprised an inner Chamber of Delegates consisting of the official representatives of the several Governments. It will be remembered that, in 1881, the French Government appointed no fewer than 75 French delegates in a chamber consisting of little more than 100 members. In the present case, the United States Government appointed only five, and allotted an equal number to the three great powers, England, Germany, and France, other nations having fewer. The chamber sat with closed doors, but admitted by invitation as visitors, without voting power, a few electricians, mostly German and American, whose knowledge of the subject of units rendered their presence of special value. The Congress at large had, as acting chairman, Dr. Elisha Gray, of Chicago, so well known for his pioneer work in telephony and harmonic telegraphy, and lately for his telautograph. At its first assembling, it elected by acclamation as honorary president His Excellency Dr. von Helmholtz. It has also as presidents of its three sections, Prof. Rowland, Prof. Cross, and Prof. Houston. Its general secretary was Prof. Crocker, who, unfortunately, was only so chosen after the meeting of the Congress. Had he been appointed beforehand, much valuable time that was wasted on preliminary arrangements would have been saved. And here a word of explanation as to the loose character of the arrangements made for the accommodation of the Congress may be recorded. Had the electrical men of the

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States held the control of affairs, no doubt the whole from first to last would have been carried through in a business-like way, with efficiency, and dispatch, and method. But, unfortunately, since the Congress was supposed to be in some way connected with the World's Fair, the work of preliminary preparation was committed to a semi-official organisation known as the World's Fair Congress Auxiliary, presided over by an utterly incompetent and fussy official of the name of Bonney, who sought to magnify his office by calling together in Chicago no fewer than one hundred and fifty different Congresses on all topics from religion to piano-tuning. Of these there was a large number going on every week; the Electrical Congress week witnessing also Congresses on Astronomy, Spiritualism, Africa, Chemistry and Freemasonry. Persons accustomed to the good organisation of the meetings of the British Association were horrified to find conspicuous by their absence all such features as the daily programme, the reception-room, the printed list of members, and the like. The list of Papers to be read (not in their order), though prepared on the Friday evening for the Press, was not ready for distribution till Tuesday. The rooms chosen both for the general session and the section-meetings were intolerably noisy—opening upon a busy station of the Illinois Central Railroad. And no provision was made for securing proper reports. The daily newspapers of Chicago city made no efforts to give useful reports, and sent reporters destitute of any technical competency, who merely chronicled trivial personalities. On the other hand, great efforts were made by the proprietors of three leading technical electrical journals to produce reports of the Congress with promptness. Such alertness on their part made the incapacity of the daily papers seem even more glaring. This Congress, the only official one of all the series, was treated as though it had no more significance than a Congress on chess-playing. It was entirely ignored by the municipality, and by the prominent citizens of Chicago. If it had not been for the personal exertions of Dr. Elisha Gray, of Prof. Carhart, and of some of the more active members of the American Institute of Electrical Engineers, who at an early date took an active part in foreshadowing the arrangements to be made, the whole thing would have been a melancholy fiasco. Englishmen knowing the difficulties which their American brethren may have to meet from the incompetence of officials who owe their appointments to political influences, can make allowances. What their Continental brethren may have thought of such a discreditable state of things may be imagined. After the opening session of the General Congress, with its speeches of welcome, sectional meetings were held. Section A, on topics of Theory under Prof. Rowland, met next morning only to adjourn, being unable for that day to discover what business there might be for it to transact. Sections B and C, which were respectively devoted to Mixed Theory and Pure Practice, were more fortunate, and held active sessions each morning, and were attended by considerable numbers. The chief discussions, some of which had to be adjourned, were on the subjects of Long-distance Transmission of Power, Multiphase Motors, Phenomena of the Arc, and Ocean Telephony. Prof. Ayrton's Paper on the arc will probably be the most enduring in note of all the Papers read. Mr. Preece's account of his experiments on telegraphing without wires was also well received.

The Chamber of Delegates, under the Presidency of Prof. Rowland, of Baltimore, met usually in the afternoons. It set to work first upon ratifying the fundamental electrical units in such form as to meet with international agreement. There was little dissension as to the actual end to be arrived, but much discussion as to the form. After it had been agreed to adopt as the international standard of resistance the mercury-column ohm 106·3 centimetres in length, there arose a prolonged wrangle as to whether this should be taken as a primary standard or not. Prof. Mascart desired that this material standard should be decreed to be the ohm without any reference to the centimetre-gramme-second system of units from which it is supposed to be derived; just as the international metre is defined as a certain bar of platinum without reference to its supposed relation to the quadrant of the earth's meridianal circumference. On the other hand, Prof. Mendenhall strongly urged that the abstract definition as 10^9 in the C.G.S. system should be retained. Eventually by the appointment of a small sub-committee to settle the wording, a compromise was arrived at which leaves the definition in entire accordance with that already accepted in England, Germany, and France. Similarly with the definitions of the ampere and the volt, compromises were finally voted with unanimity. It was curious to note that M. Mascart, who had stood out on the ohm as the champion of the material standard, advocated equally succinctly the definition of the ampere as an abstract unit without reference to any material way of reproducing it, whether by silver deposit or by some standard gravitational ampere-meter or electro-dynamometer. M. Mascart denied the precision of the silver deposit, and was supported by his Excellency Von Helmholtz. Profs. Carhart and Rowland equally impugned the possibility of getting an absolute reading correct to 1 part in 10,000 by either electro-dynamometer or by tangent-galvanometer, unless in some special research of extraordinary precision. Then the question was raised whether, supposing the ampere should be defined only in terms of the ohm and volt, the latter could be more accurately defined in terms of absolute value than the ampere could be. It was urged that Clark's cells could be made easily to agree to within 1 part in 10,000 to one another. On the other hand, it was doubted whether the absolute value of the cells so agreeing with one another was determined with anything like that accuracy. It was pointed out that the Congress of 1881 defined first the ohm, then the volt, and took the ampere as the mere sequence of these two. Was it well now to reverse the order, and define the ohm and then the ampere, leaving the volt to be defined in terms of that pair of units? Of course in the abstract relations of the C.G.S. system the order was immaterial; but M. Mascart's proposition was to define the ohm in the concrete and the ampere in the abstract; which would necessitate a definition of the volt as that electromotive force which would send the abstract ampere through the concrete ohm. Eventually these matters were referred, as the ohm had been, to the small sub-committee to frame language, and its report, moved by Prof. Mendenhall, and seconded by Dr. Budde, was unanimously adopted. It defines each of the units as an abstract quantity, but adds in each case the practical standard by which in the present state of science the unit may be sufficiently closely represented for legal purposes. To distinguish these units as now defined from the definitions given by previous meetings or Congresses, they are denominated the "international" ohm, the "international" ampere, &c. The wording of the schedules in which are to be described the details of the processes of silver-deposit, for the ampere, and of construction of Clark's cells, was relegated to a sub-committee consisting of Prof. Von Helmholtz, Prof. Carhart and Prof. Ayrton. The definitions of the farad, the coulomb, the joule, and the watt were accepted without much debate as the logical consequence of the three units first decided. Over the proposal to recognise the "henry" as the unit of self-induction there was much discussion. Everybody appeared to be willing to agree to the proposal to adopt the name of "henry" (in honour of Prof. Joseph Henry) in place of the impersonal (and incorrect) name of "quadrant," selected by the Congress of 1889; but no one seemed to be quite ready to define the quantity to which the name was to be attached. It was pointed out that mutual induction must be expressed in terms of the same unit as self-induction. Eventually, an understanding was arrived at. M. Mascart moved, and Prof. Ayrton seconded, the adoption of the name "henry," whilst the exact definition was referred to the sub-committee. The new definition of induction cleverly turns the difficulty that is involved in any attempt to take into account the magnetic properties of the medium, and reconciles the two opposing views. Then came up for discussion the question of the proposed magnetic units. Should the C.G.S. system simply be adopted? Or should a "practical" magnetic system be approved having the 10^8 as a factor in it to correspond to the volt? And what should be the names given to such units? Prof. Rowland objected to any extension of the "practical" system with its eighth and ninth-power exponents, into the magnetic part of the subject; urging, as one reason, that the designers of electromagnetic

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apparatus do not use anything except the C.G.S. system. He also objected to multiplicity of names. Some attempt was made to secure the adoption of the name of "gauss" for the C.G.S. unit of magnetic field, it being alleged that for want of some such name incorrect designations were sometimes given; as, for example, where the horizontal component of the earth's field is described as being 0·18 *dyne*. A majority of the delegates failed to see the force of this argument. It was moved by Mr. Siemens, and seconded by Prof. Nichols, that the C.G.S. units of magnetism be adopted without names, and this was carried. The question of the scientific designation of the brightness of electric lamps was then introduced. What was a 1,000-c.p. lamp? Was it one that only measured 1,000 in one particular direction? It appeared that certain American contractors, not of the first rank, had been in the habit of describing a certain kind of arc lamp as of 1,000 c.p., which in fact was far from being such. The law being apparently powerless to deal with such frauds in the absence of any recognised definition* of candle-power, decision was asked on the point. It was suggested that lamps should be defined in terms of watts, not of candle-power. American delegates protested that this would not protect the consumer from having imposed upon him an inferior lamp which for the same number of watts gave less candle-power. It was pointed out that under the British Electric Lighting Acts the undertaker cannot prescribe to the consumer what sort of lamp he must use, and leaves the consumer free to use any lamp that is adapted to the declared pressure or current. It was eventually decided that the difficulty being a purely national, and not an international one, arising mainly out of the circumstance that American municipalities have not yet adopted the wholesome practice of calling in some responsible consulting engineer to advise them upon the terms in which their contracts should be drawn up, the Congress could not interfere. But the discussion served to emphasise the uncertainties which exist in the absence of working methods of measuring colour and of a suitable integrating photometer.

Two other questions which were referred by the chamber to the sub-committees received anxious consideration, and were keenly discussed before being reported upon. One of these was the proposal for a system of uniform notation; the other related to the standard of light. The array of symbols proposed by M. Hospitalier was championed by him with ability and eagerness, and was with some amendments adopted by the sub-committee and received by the chamber (but not for official adoption) and ordered to be printed. Some of its details seem open to severe criticism, but if only they could be universally adopted how convenient they would be! The proposal of Drs. Budde and Lummer to adopt as a standard of light the Von Hefner lamp, with its reddish flame of acetate of amyl, was no less emphatically urged. There was no other practical lamp of equal constancy—within 2 per cent.—and the molten platinum standard was not realisable; then why not adopt it as *the* standard? It required much backbone on the part of English, French, and Swiss representatives to resist the vehement plea. But, with the possibility of a simple and better electric standard looming in the near distance, giving a really *white* light of fixed brightness as a standard, it was clear that no proposal for a flame standard would be acceptable, and certainly not this amyl-acetate flame, however excellent may have been the results obtained at the Reichsanstalt. And so the sub-committee, under the presidency of M. Violle, arrived at the inconsequent conclusion that they were not able to report in favour of any standard at present.

All too soon the five days of the Congress came to their end, and the final meeting was held to announce the decisions arrived at, and to thank our American hosts for the courtesy and hospitality with which they had received their guests. Dr. Elisha Gray, in finally responding with characteristic simple dignity, thanked all members present for their help, and begged those who came from foreign shores to Chicago not to think only of its smoke and noise and tall buildings, but of warm hearts praying that they might have smooth seas and a warm welcome home. And so with the inevitable accessories of photographs of groups, of a festive banquet, of a reception by the British Commission, of midnight speeches at the Electricity Building, and of newspaper portraits mainly of celebrities who never came near the meetings, the Chicago Congress vanished into the past.

* An amusing illustration of this inaccuracy is afforded by the way in which the search-lights at the World's Fair are grandiosely described as being of "one hundred and ninety million" and "two hundred and forty million" candle-power. It is known that an arc light of even one million candle-power would require nearly a square foot of *crater* area. Certainly the carbons used in these lamps did not possess cross-sections of a hundred and ninety or of two hundred and forty square feet. They had not even a section of one square foot.

ON METHODS OF OBSERVING ROTATIONS BY MEANS OF INTERFERENCE FRINGES.

BY PROF. GEO. F. FITZGERALD.

The principal difficulty in estimating rotations by direct observation of a rigid body, such as a pointer, is to distinguish between a rotation and a displacement of the centre of suspension. An application of the principle that Michelson employed for separating double stars might be used. In this method the central parts of a mirror are done away with, and only the extreme edges at opposite ends of a diameter employed to send light to a common point where the interference bands are observed. In the case of a galvanometer needle, for instance, as one of many methods, two very small scraps of mirror, parts of the same plane, might be supported on opposite ends of a long pointer, and a divided beam reflected from each might be recombined so as to produce interference fringes. A common motion of the two mirrors, in or perpendicular to their own plane, would not make any difference of path in the two rays, but any rotation would produce a change in the fringes.

It is doubtful, however, whether this would really be much more efficient than the simpler and more easily arranged method of observing, by means of a double-nozzled microscope, both ends of a pointer in a common field of view, and measuring the change in distance between the two images with a micrometer eye-piece. This change is independent of the translation of the pointer, and depends only on its rotation. Photography might be applied to both methods with advantage.

ON THE CHANGE OF ELECTROMOTIVE FORCE OF A GALVANIC ELEMENT WITH THE TEMPERATURE.*

BY A. GOCKEL.

Von Helmholtz has stated that for the combination $Hg, HgSO_4, ZnSO_4, Zn$ the thermal change of a galvanic element can be represented by the algebraic sum of the thermo-electric forces appearing at the different points of contact. The author, in a former work, took this as true also for a Daniell cell; but afterwards G. Meyer (*Wied. Ann.*, 33, 265-288) found, in experimenting on this element, that in general the temperature coefficient of the couple cannot be determined from those of the separate contacts. The author, therefore, resolved to make investigations both with the Daniell cell and with other combinations as arranged by Helmholtz. The results for thirteen different cases bear out Helmholtz's conclusion.

The arrangement of the experiment was as follows:—Four vessels, A, *a*, B, *b*, consisting of test tubes 12cm. high and 5cm. wide, were closed by perforated corks, and each pair connected by 12mm. syphon tubes, in the middle of each of which was a branch for filling it. A and *a* were filled with zinc sulphate solution, and a zinc electrode was placed in each. B and *b* contained copper sulphate in solution and a copper electrode each. The tubes A B and *a b* were filled with zinc sulphate solution, so that there were two Daniell elements, of which one could be heated in a water bath, while the other remained at the temperature of the room. By connecting them in opposite directions the difference in the electromotive forces could be determined. If, on the other hand, the tube A *a* is filled with zinc sulphate solution, the thermo-electric force of the combination Zn (hot), $ZnSo_4$, Zn (cold) can be determined. If the tube B *b* is filled with the same solution we can measure the thermo-electric force of Cu (hot), $CuSO_4$ (hot), $ZnSO_4$, $CuSO_4$ (cold), Cu (cold). By filling the tubes B *b* and A *a* with copper sulphate solution other corresponding combinations can be investigated, and similarly with the remaining combinations.

The measurements were taken with a Thomson's astatic galvanometer of 500 Siemens' units resistance. The tubes were closed with parchment paper. The temperatures varied from 0° to 40°C.

* *Weid. Ann.*, Bd. 40, Heft 7.

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The Electrician.

(The Oldest Electrical Journal.)

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.
Editorial, Publishing, and Printing Offices:
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.

Telephone No. 2714. Telegrams: "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "Coutts and Co."

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All letters intended for insertion in "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as evidence of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. It is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices.*

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"NEW LAMPS FOR OLD."

The reduction in the prices of glow-lamps which took place last week may or may not alter the quality of the lamp to which we have become accustomed, namely, the excellent lamp produced by the Edison and Swan United Company. The altered condition of the business will no doubt to some degree affect the process of manufacture, but whether these lamps maintain their good qualities, in order to compete by their merits with the numerous kinds which will be shortly offered, or whether, being produced at a lower price, a slight but not equivalent lowering of the quality is found, it is certain that many other glow-lamps which will be made in and imported into this country will be of an inferior kind. One of the great difficulties with which the public will be met is that it is impossible, we believe even for an expert, to judge whether the lamp which he may buy across the counter is a good or a bad one. Hitherto reliance has been very properly placed on the *bonâ fides* of the Edison-Swan Company. Of course a lamp can be lit up to see whether the filament is properly suited to any particular voltage, and a purchaser can judge by eye whether it is overstrained or not;

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but the life, and the inevitable falling off of the candle-power, he cannot even guess. It can only be measured by prolonged observation. In some cases, unscrupulous makers of glow-lamps, before they were finally suppressed by the Edison-Swan Company, have, at all events, in one instance that we remember, deliberately offered 45-volt lamps, or lamps which ought to have been called 45-volt lamps, for use on a 50-volt circuit, and pointed out their great brilliance as a manifestly valuable consideration. Several months will elapse before even experts will be able to judge of the real qualities of the new lamps which will shortly be offered. In the abstract which we are giving from the work of Mr. RAM upon the manufacture of glow-lamps a few of the more important tests of lamps will be found; photometric tests, for example, will be found in our present issue, and wattmeter tests will appear next week.

The sale and manufacture of glow-lamps is as distinct from the supply of electric energy by the supply companies as is the sale of gas burners from the sale of gas; more so, indeed, for many of the gas companies supply, and supply at specially low prices, various gas-consuming appliances. With the exception of the letting of meters, electric supply companies have no concern in the sale of electrical apparatus. In the early days of electric lighting makers of gas burners—and there are, by the way, only a few of these in this country—naturally inquired into the commercial details of their threatened rival, and turned their attention to the price of glow lamps. The 3s. 9d. was so much greater than the price of an ordinary gas burner, and the life of a lamp confessedly so much shorter than that of a gas burner, that without regarding the cost of electric supply, of which little was known, they naturally supposed that the whole of the cost of electric lighting would depend largely on the price of lamps, and it seemed probable that the cost of the lamp would have to be greatly reduced before it could compete with gas. In one sense they were right, for there are really in this country few cases, if any, in spite of the ingenious calculations of several leading authorities, where electric lighting by glow-lamps has been able to compete with a good gas lighting if mere price is alone considered. In the important article by Prof. AYRTON, which we print this week, besides much that is of interest concerning the tests of glow-lamps at the Central Institution, a careful comparison is made between the cost of lighting by gas and by electric light. It appears that it is only under the altered circumstances of cheap lamps, over-running, and supply at 4d. per unit that competition in mere price begins.

It will be evident to all those who have given any attention to the characteristics of the modern glow-lamp, that a reduction in prices must be considered in connection with the so-called efficiency of watts per candle. It is only fair to assume, as we have done on a previous occasion, that the Edison-Swan United Company have considered the best interests of their customers in recommending a certain kind of lamp, which they call a 100-volt lamp, to be run upon a 100-volt circuit. It is generally supposed, but has never been acknowledged by the makers, that the life of such a lamp has been about 1,000 hours. The variation of the voltage of most electric supply companies is, however, so great that no very accurate tests of the life of lamps can be made. The life under a mean pressure of 100 volts, when there is a variation within certain limits, is less than under a constant pressure of 100 volts. There has been no reason to suppose that the Company have suggested that their lamps should be overrun for the purpose of increasing their sales. On the other hand, it appears that in the United States, companies who supply both electrical energy and lamps are frequently in the habit of underrunning their lamps, and of giving their customers a very inferior quality of light, with the view of lengthening the lives of the lamps. It is evident that as the price is now considerably reduced it will pay to overrun lamps, both as regards the cost in mere shillings and pence, and for the sake of the improved quality of the light. M. HOSPITALIER has recommended consumers to smash their lamps at a certain point at which they become unprofitable servants. This is a rather exaggerated view to take, and among the many interesting points brought out in Prof. AYRTON'S article, it is clear that it may under certain circumstances be worth while to send half-used lamps from Eastbourne to Newcastle, the lamps having arrived at the Eastbourne smashing-point, and, still remaining, worth a few pence to canny Newcastle consumers. Prof. AYRTON provisionally recommends that 100-volt lamps be run at 104 volts, or, what is the same thing, 97-volt lamps should be run upon 100-volt circuits. It is probable that the curve of total cost will be found to be so flat at its minimum point, that with no great extravagance we might use 96-volt or even 95-volt lamps for the sake of the whiter light, and at a very slight increase of total cost. Prof. AYRTON, however, already assumes that the life of the lamps may be reduced, for purely economical reasons, to 200 hours, and here we are confronted with the nuisance of continually replacing lamps, consequent upon the perhaps still greater nuisance of frequent sudden extinctions. In large public buildings where many glow-lamps are used, burned-out lamps are often to be seen, and the trouble continually of replacing them is no small matter; while in domestic lighting the sudden failure of a single lamp which has been used for the illumination of a room is felt as a distinct drawback, but one which is to be set off against the many useful conveniences of electric lighting. If, however, the life of lamps really becomes naturally reduced to 200 hours, the use of lamps in pairs will have to be much more common, but such a practice already carried to an unwise extent, at once doubles the cost of lamp renewals, since in most cases a 16-c.p. lamp costs no more than an 8-c.p. lamp.

REVIEWS.

Minutes of Proceedings of the Institution of Civil Engineers, 1892-93. Parts I., II., III. Edited by JAMES FORREST, Secretary. Published by the Institution.

The first of these volumes contains no Papers directly bearing on electrical engineering, unless a "selected Paper" by Mr. A. Brebner on "Relative Powers of Lighthouse Lenses" can be thus included. The Paper is of an intricate character, and the author shows that plano-convex lenses are superior to sphero-convex lenses. The effects of different sizes of flame are considered, and a case in which a flame of 46·55mm. radius, subtends an angle of 4deg. to the nearest point of the lens, is discussed in detail. No allusion is made to electric lights in the Paper, but it may be mentioned that the light-giving part of the arc at St. Catherine's Point is about 20mm. by 6mm., and may be considered as a short flame of 10mm. maximum radius, or a mean radius of about 6·5 mm.

The second volume contains the important Paper by Mr. J. E. Dowson on "Gas Power for Electric Lighting," an abstract of which has appeared in these columns. He made no comparison between the use of town gas and of generator gas, but urged the many advantages of gas power over steam power, particularly for electric lighting purposes. Both the Paper and the Appendix contain a large number of tests giving very full information on fuel consumption. The discussion was comparatively uninteresting, and was used as an opportunity for inventors and others to describe new engines, self-starters,

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which, by-the-bye, would be of little use in a central station, and the comparison of "Otto" and other cycles.

Prof. Kennedy confined his attention to the subject of the Paper. He had found it was possible to reduce the standing loss of steam boilers which were not making steam, to about 10 per cent. of the whole consumption in all the boilers of a station. He found it difficult to get a load factor of more than 65 or 70 per cent. The ratio which he called the load factor was obtained in this way: he took the number of engine hours per week; he multiplied the hours worked by each engine by its full-load output, and added the products together. He thus found how much the station would have done with the same engines working the same number of hours if they had been running all the time at full load. He compared this with the actual output during the week, and the result was about 65 per cent. The comparison could only be fairly made by figures taken from week's end to week's end, including all the nights and all the Saturdays and Sundays, and so forth. He used non-condensing engines which always gave a test result of 24lb. of steam per electrical horse-power hour at the terminals, which was equivalent to 32lb. of steam per unit. He used boilers which gave 11lb. of steam per lb. of coal, under standard conditions (that was about 9½lb. of steam actually sent to the engines) also on test. He ought, therefore, to use about 3·4lb. of coal per electrical unit delivered; instead of which, in January last, he had obtained at two stations a figure which averaged 5·3lb. That was much better than the average of the year, but he gave the figures as they occurred. He accounted for the difference, which was 1·9lb. per unit, in this way: "First of all, 10 per cent. stand-by boiler loss, 0·53lb. Then he knew from experiment that, working at 65 per cent. load-factor on the engines, he lost about 25 per cent; that was, the steam per electrical horse-power hour would be increased 25 per cent., so that there was 25 per cent. engine loss on 3·4lb., or 0·85lb., and adding that to the 0·53, gave 1·38lb., leaving 0·52lb. still to be accounted for by the load-factor of the boilers, and by all the miscellaneous losses in the station." Mr. Kapp gave some figures showing that with a private electric lighting plant generating 74,229 units during the year 1892, the cost of a unit came to 3·03d.; and Mr. Thomas Preece contributed some particulars of the Dowson gas plant at Morecambe.

In the same volume, Dr. E. Hopkinson's Paper on "Electrical Railways" is published. It occupies only twenty-two pages of the *Proceedings*, and of these, twenty relate to the City and South London Railway. Not only the length but the contents of the Paper are very disappointing. Contrary to the custom of authors of Papers dealing with works of construction, no reference whatever is made to the early difficulties of the undertaking. The engineer of a successful work can always afford to describe difficulties and even failures when he can point to eventual triumph over them. It would have added considerably to the interest of the Paper if some of the stories about the early experiments on this line had been either refuted, confirmed, or better still, authoritatively narrated. We have heard, for example, thrilling accounts of some of the first runs, how the resistances or other part of the gear gave way, and fused, and how the locomotive ran away, the drivers being driven by blazing arcs, showers of molten copper and green fire, to take refuge in the train; and how, as they lay on their faces on the floor of the last carriage, the train flew on to destruction—or to Stockwell! This tale even if modestly edited would have given some life to the Paper.

The space of a page is occupied by a remarkable apology for the use of the jockey pulleys at Stockwell. The condition $V = \sqrt{T/m}$ is to be observed, V being the velocity of the belt, T the tension, and m the mass of unit length of belt. Under these circumstances the author says that a wave on the slack side of the belt "will be stationary in space, tending to maintain the deformation of the belt round the jockey pulley." More mathematics follow, and some data about the belts which appear to fit the formula. The number of mishaps which took place at Stockwell before the belts learned to conform themselves to the formula, and the amount of damage done by hopelessly ignorant and obstinate belts was not recorded. For the purpose of a lecture experiment this theoretical condition might perhaps be maintained long enough to exhibit to an audience, but at a power station, especially at one where the governors appear to be capable of some improvement, this explanation is ridiculous. If the jockey pulleys do not heat, that is sufficient proof that no waste of power is present there, and as long as the belts do not wear out, the power lost in them does not in all probability exceed more than three or four times the loss that would occur with long centres. Some arguments for and against gearless motors are given, and a discussion on the efficiency of the whole system extends over four or five pages. The Paper added but little to the already published descriptions of the line.

In the discussion Mr. Kapp suggested the use of one or two shunt motors at intervals along the line, each driving a fly-wheel, but doing no other work. Fly-wheels 6ft. in diameter, weighing two tons, would deliver 45 H.P. for one minute with a variation of speed from 700 to 500 revolutions per minute. The motors would run all day, taking up power when the load on the line was light, and give out power and lose speed when the heavy strain came on. Mr. Greathead brought some real engineering into the discussion, and gave a good deal of interesting information. He described several diagrams showing the speed, current, volts and electrical horse-power during an up and a down journey of a single train, and the electrical horse-power delivered from the station when seven, nine and ten trains were running. These curves showed the enormous expenditure of power at starting, partly due to work necessarily done in acceleration, and partly to the consumption of current, the useless volts being wasted on the regulating resistances. The great objection to geared locomotives, at any rate in connection with tunnel railways, was their intolerable noise. There was one such locomotive, but it was seldom used, as it could be heard three-quarters of a mile away. A great deal of trouble and loss had been occasioned to the Company through damage to the armatures, resulting, he believed, entirely from the rush of current through the motors at the start. The remedy was found by Mr. Basil Mott, the resident engineer on the line, who wound a number of the armatures with square wire instead of round, and there had been no trouble since with them. Mr. W. W. Beaumont described two forms of gear for connecting the armatures of a locomotive to the car axles for the purpose of enabling the smaller motors to start the train, and thus to avoid the great losses of current and to facilitate starting. These gearings have been recently modified by Mr. Beaumont, and are described in our present issue. The remainder of the discussion did not add much to the general knowledge of the subject; but the author's reply contained a few interesting details. He attributed the breakdown of the armatures to the overloading of the armatures. The wire with which they were wound was covered with two layers of cotton, with a layer of india-rubber between. The india-rubber was destroyed by the heating due to the increased load. The weight of the carriages originally specified was 4½ tons, but the carriages actually used weighed 7 tons. In the correspondence upon the Paper, which is often an important feature of the proceedings of the Institution of Civil Engineers, Mr. A. Campbell Swinton made an independent suggestion of the same nature as that of Mr. Kapp. He suggested the use of a steel fly-wheel, weighing about 6 tons, and measuring 3ft. in diameter and 3ft. wide, running at 4,000 revolutions per minute, and sufficing to maintain 66 H.P. for two minutes with a variation of 5 per cent. of the speed. He proposed to apply such a fly-wheel to a steam turbine at the generating station.

Among the selected Papers in this volume is one by Dr. Preller upon the water-power supply and electric works at Zurich.

The third volume contains no electrical Papers, but it was rather surprising that during the discussion which followed Mr. Sopwith's very interesting Paper on the breakdown of the "Umbria," no allusion should have been made to the use of electrically-driven drills and other portable tools, by which such a repair could be greatly facilitated. Among the selected Papers is one on Wheel Teeth by Mr. A. Sharp, which deserves the attention of all engineers who have to design or construct gear wheels.

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THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 557.)

After the lamps have been sealed up and removed from the pumps, the vacuum is usually tested by means of an induction spark. An induction coil is fitted up in a dark room or closet, and is arranged so that it would give a spark of about ⅜in. in length. The terminals are, however, set at a greater distance apart than this, so that no spark passes. The lamp to be tested is then taken in the hand, and its terminals are held against one or other of the secondary terminals of the coil. If the vacuum is very poor, the lamp will glow all through, even before it touches the coil. If it is better than this, however, but still not good, there will be a glow all through the lamp when its terminals touch the coil. If the vacuum is good enough there may still be a considerable amount of glow, but it will all appear upon the inside surface of the glass, and not at all in the interior of the lamp. The glow in the interior of the lamp in the case of a bad vacuum will be of a blue colour, or if the vacuum is very bad, of a purple colour. In the case of a good vacuum, when there is a glow upon the glass only, it will be blue if the bulb is made of lead glass, but of a green colour if German glass is used. In the case of a good vacuum the glow on the glass is not continuous, but is intermittent, and it only appears in patches, or there may be no glow to be seen at all. With a good vacuum, while one hand holds the lamp to one terminal of the coil, the other hand may grasp the other terminal with impunity; whereas, if the vacuum is bad, a shock will be felt.

The coil test is, however, not infallible. A lamp which shows a poor vacuum may, by being run very bright for a minute or two, be made to show a good vacuum on the coil, no trace of any glow being perceptible. Advantage of this phenomenon is taken by pump-room operatives, if not properly looked after, for getting poor vacua passed as good ones.

The coil test is sometimes applied to the lamps, while still on the pumps, in order to ascertain if they are ready for sealing off. It is more bother than it is worth, however, to do this, as the effect cannot properly be seen except in the dark.

The process of exhausting lamps with mercury pumps is costly and slow. Any mechanical pump which could quickly and with certainty produce a sufficiently good vacuum would be welcomed by lamp-makers. The difficulties in the way of constructing such a pump are many. One great difficulty is that of preventing leakage through the glands and past the piston. Another trouble is that the working parts require lubrication. If oil is used, there will certainly be vapours given off, which will prevent a good vacuum from being obtained. A pump was exhibited in Boston, U.S.A., about three years ago, in which all the difficulties were stated to have been overcome. It was said to exhaust lamps in a far less number of seconds than a mercury pump would do in minutes. The chief point about this pump was that the working cylinder was enclosed in a vacuum jacket. In this way all leakage into the working cylinder was prevented. Oil was, however, used in the pump. As nothing appears to have been published regarding this pump since it was first exhibited, it is to be presumed that its performance did not after all come up to the expectations of the inventors

An ingenious mechanical pump, containing mercury in the cylinder, was patented in 1882 by Gimingham, but the author does not know to what extent it was found to answer.

Pumps for producing the vacua for working the mercury pumps and for flashing, &c., do not require to be of any very special construction. The valves must, however, be opened and closed by direct mechanical action, and should not depend on the pressure of the air. Silk valves will not answer, as they wear out much too quickly, and are not suitable for large pumps. The Packard vacuum pump, manufactured in Brooklyn, U.S.A., is largely in use in America.

The lamps having been exhausted are next tested for voltage and candle-power. For this purpose it is necessary to have a photometer and instruments for measuring the current strength and the pressure. The object of the test is to find at what voltage the lamps must be run in order that they shall be at the right temperature; the temperature, that is, at which they are required to be run, 3, 3½, 4, or other number of watts per candle-power as desired.

In some factories only a few lamps are tested on the photometer, and the other lamps are compared directly by eye with these. Thus, if 100 volt lamps are being made, lamps will be selected by the photometer which run at the required temperature, at, say, 94, 96, 98, 100, 102, 104, and 106 volts. These seven lamps are all hung up in a line. The lamps to be tested are lighted up on the same circuit, and in close proximity to the standards. They are then labelled according as they are found to compare with the standards.

This is not, however, a satisfactory method of testing. The eyes of the tester soon become unreliable, and refuse to see considerable differences in the temperature of the filaments. Darkened glasses may be used to save the eyes from the injurious effects of continually looking at the bright filaments, but they do not make the testing any easier.

Far greater accuracy can be obtained by testing each lamp separately on the photometer. Those accustomed to make photometric tests of lamps in the laboratory will, perhaps, think that it would be impracticable to test every individual lamp owing to the time occupied in making the test. A photometer can, however, be arranged for the lamp factory so that the testing can be done very quickly. A thousand lamps a day can easily be tested on one photometer, provided that the lamps do not differ greatly from each other; that is to say, that 100 volt and 70 volt, or 8 c.p. and 20 c.p. lamps are not all mixed up together. In the laboratory the testing apparatus is conveniently arranged for the observer to be able to read the photometer and the different instruments without moving from his seat. In the factory, however, for rapid testing, the apparatus is arranged so as to be operated by two or three persons. A wattmeter is also required in addition to the other instruments. A wattmeter is not a necessity in the laboratory, as the calculations can be done on a slide rule with sufficient rapidity; but it is essential for factory testing, as it does away with the necessity for making any calculations whatever.

The great trouble in all photometric measurements is the want of a really good standard of light. The light of the incandescent lamp is estimated in candles. Standard candles are, however, of absolutely no use for factory lamp testing, and are of little value as standards under any circumstances.

The most reliable standard of light is the Harcourt pentane lamp (second pattern). It is simply a lamp burning the vapour of standard quality pentane. It is arranged so that the same size of flame, giving a light of one or two average standard candles, is always presented to the photometer. It is, however, more of a laboratory standard than one fitted for constant use with the factory photometer.

For actual use in the factory an Argand burner, burning ordinary illuminating gas with a Methven screen, is preferable, as it requires less attention. The chief trouble in using an Argand burner, even with a Methven screen, is due to the flickering to which the flame is liable if there is the slightest draught. This can, however, be remedied by enclosing the burner in a large box having openings sufficient only for the proper supply of air to the flame. The Methven screen, it is well known, is simply a metal screen with a hole in it of such a size as to only allow a small piece of the centre of the flame to throw any light into the photometer, the light from this piece of the flame being very much more constant than is that of the whole flame.

The position of the Methven Argand standard is adjusted by comparison with the Harcourt standard, and can be checked by it as often as is thought necessary. If the lamp factory has a separate laboratory, with a photometer and testing instruments, it is more convenient to test a lamp in the laboratory, using the Harcourt standard, and then to give the

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same lamp to the testers in the factory testing room, and see if their test of it agrees with the laboratory one. A convenient way of keeping a check on the testing is to keep one or two lamps to be always tested first whenever the photometer is used. As long as these standardised lamps always test the same it may safely be assumed that the whole apparatus is in good order.

It is not intended here to go into the matter of photometry and lights standards generally, as there are already works upon the subject. An excellent one is that by Mr. W. J. Dibdin, entitled "Practical Photometry," which, although it deals chiefly with gas-testing, contains much information, useful also to the incandescent electric lamp tester.

In testing incandescent lamp the object, as already menioned, is to find what difference of potential must be applied at the terminals of the lamp in order that it may be maintained at a definite temperature or efficiency in watts per candle-power. It is therefore necessary to light up the lamp and ascertain the amount of power it is taking, and then see if it is giving the required amount of light for that amount of power. If the lamps are to be run at 4 watts per candle-power, then for every 4 watts supplied to the lamp it should give a light of one candle. If the lamp when lighted up is found not to give as much light as one candle for every four watts, or is found to give more than that amount, then it must be run brighter or duller by applying a greater or less difference of potential until it attains the required degree of brilliancy. When the adjustment is found to be correct the voltmeter indication is read, and the number of volts registered is the proper voltage for that lamp.

This system of testing, which was introduced by Mr. Swinburne, is the only correct one. It is obvious that if the lamps are tested at a fixed voltage or candle-power they will vary in brightness and efficiency (watts per candle-power) unless they are exactly alike in every particular, whereas by this method they are tested at a fixed brightness and efficiency, and the voltage and candle-power are assigned in accordance therewith. The way in which the author has used the method in the lamp factory will now be described.

The photometer table is at such a height above the floor that the lamp and the photometer disc are on a level with the eyes of the observer when sitting comfortably in a chair. The gas lamp with its Methven screen and the disc box are at the right hand end of the table, the lamp under test being on the left hand of the observer. The photometer bar is graduated directly in candles, the zero point being immediately below the disc. The candle-power graduations are proportional to the square of their distance from the zero line.

The lamp is carried in a frame which can be moved to and fro along the photometer bar by the observer at the disc. The lamp holder is also capable of being raised or lowered and rotated. There is also fixed to this frame another bar, also divided into candles, but having its zero mark at the lamp end. This bar slides backwards and forwards with the lamp frame, and the observer at the photometer is therefore able to read the candle-power of the lamp by the indication on this bar at the zero line immediately below the disc, and does not have to look along the bar to where the lamp happens to be in order to get the reading. This is a great convenience, as the observer does not get the light of the lamp into his eyes, as is the case in the former method.

The wattmeter is fixed on a shelf just behind and above the disc box, so that its indications can be readily seen by the observer at the disc, the scale of the instrument being an upright one, and not one that has to be looked down upon.

There is a large screen all round the disc box, so that the observer at the disc does not see any light except that upon the disc. No light from the lamp under test or the gas lamp can fall upon his eyes. The watt-meter scale is illuminated sufficiently by a small incandescent lamp run very dull. The scale of candles on the movable photometer bar being large and on a white ground can be read by the small amount of diffused light from the lamp under test. In this way there is no light which can upset the eye of the observer.

The switch and variable resistance for adjusting the current as well as the handle for moving the lamp to-and-fro are fixed in a convenient situation for being worked by the observer. The voltmeter (and ammeter, if used) is situated on the other side of the screen surrounding the observer, and is read by one of the assistants. The method of working is as follows:

The tester-in-chief sits at the photometer. In this position he can see the disc box, the wattmeter scale above it, and the candle-power scale below it. He does not see either the lamp under test or the standard gas burner, nor yet the voltmeter nor ammeter. He has the control of the current and the motion of the frame containing the lamp under test. There are two assistants on the left hand of the tester, one on each side of the photometer table. The lamps before being brought into the photometer room have each had a small label stuck upon the neck.

Assistant No. 1 puts a lamp into the clip or holder in the movable carrier. If the lamps are supposed to be 16 c.p. ones the tester sets the lamp at the distance for 16 c.p. by the scale in front of him. He then turns the current on and brings it up until there is a balance upon the screen. He then looks up at the wattmeter scale to see how many candles the lamp should be giving for the amount of power it is taking. If the wattmeter indicates 16 candles, he tells assistant No. 1 to read the voltmeter, and whatever the number of volts happens to be that is the voltage of the lamp.

Supposing, however, when the lamp is giving 16 candles that the wattmeter indicates, say, a little over 17 candles. The lamp in such a case must then be run brighter until its actual candle-power agrees with the indication of the wattmeter. As the lamp is made brighter there is, of course, more power spent in the filaments, and consequently the wattmeter indication also rises, but, as the intensity of the light increases much faster than the power, the actual amount of light will agree with the wattmeter indication at about, say 18 candles. The balance being obtained the voltameter is read by assistant No. 1. The current is turned off the lamps, and assistant No. 2 takes it out of the holder and writes the voltage on the label, while assistant No. 1 puts the next lamp into position. If the candle-power is also to be marked on the label the assistant can ascertain its value for himself by noting the position of the lamp carrier or the fixed candle-power scale.

As most electrical measuring instruments take a perceptible amount of time to come to rest after the current is turned on, it is necessary for rapid testing that the instruments be not allowed to return to zero between the testing of each lamp. For this reason, instead of turning the current off the whole apparatus it is simply switched off the lamp just tested to another lamp of similar size located in a convenient place for giving light to the assistant testers for writing the labels and fixing the new lamp in position. The next lamp being in position, the current is switched back again, and the instruments quickly arrive at their readings, and do not oscillate as they would if they had started from zero. The instruments must, of course, be so constructed that they may be left continuously in circuit without their accuracy being impaired by heating.

The photometer room is necessarily quite dark, and painted a dead black so as not to reflect light. It should, however, be of ample size. It is absurd to locate the testing apparatus in a room in which there is hardly space to turn round, as is frequently done. It is also advisable to arrange for proper ventilation. It is not necessary, in order to keep out daylight, that the room should be hermetically sealed after the manner of the average photographer's dark room.

The tester should be in the dark room for at least 10 minutes before testing, in order that his eyes may get accustomed to the subdued light. On no account should he look at the lamp while testing, or his eye will be unreliable for some time afterwards. There may, however, be a piece of dark neutral tinted glass in the screen on either side, so that he can see the lamp and the flame of the Argand burner without any danger of his eyes being effected. The Argand burner must be lighted 10 minutes or more before it is required, as it may not give the proper amount of light until the chimney and other surroundings are at the normal working temperature.

(To be continued.)

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"NEW LAMPS FOR OLD."

BY PROF. W. E. AYRTON.

In a Paper that will be found in Volume VII. of the *Proceedings of the Physical Society* for 1885* it was pointed out, perhaps for the first time, that the proper potential difference to be employed with glow-lamps in order to obtain the greatest number of candle-hours for a given amount of money expended on lamp renewals and on coal depended on the cost of a lamp and the cost of power in the particular place, and that the most economical value of the potential difference could be found by a geometrical or by an analytical method, examples of the application of both of which to the lighting of the Finsbury Technical College were given, using the best information available at that time regarding the life of lamps when used with different potential differences.

A Paper on the same subject followed shortly afterwards from the pen of Dr. Fleming, and later on in 1888 a lengthy communication on the maximum efficiency of incandescent lamps was communicated by Mr. Howell to the American Institute of Electrical Engineers in which was repeated at considerable length the arguments and the graphical method that were contained in the Physical Society's *Proceedings* for 1885.

The numerous examples given by Mr. Howell of the application of the graphical method to practical cases did not advance the matter much, seeing that the five-years'-life tests, which he stated had been carried on in the Edison laboratory, had been made on lamps which glowed continuously for 6,000 hours, never using more than 4 watts per candle, or glowed for 1,000 hours when no more than 3 watts per candle were employed. For these excellent lamps, stated to be in continuous use in America eight years ago, have failed to cross the Atlantic in more years than it takes days for an ordinary lamp to accomplish the journey.

Later on it began to be recognised that a mere comparison of the watts per candle expended when different potential differences were maintained at the terminals of a lamp at the commencement of its life, with the number of hours that the filament would last before it broke, when the various potential differences were respectively used, did not enable a determination of the most economical potential difference to be arrived at. For it was noticed that there was a serious diminution of the light emitted as the lamp grew older, even when the normal potential difference was maintained, and it was suspected that the curve of diminishing light had possibly a very different shape with a high-potential difference from what it possessed when the normal potential difference was employed.

This deterioration of a lamp with time also led many writers to prove, and possibly a stray user of lamps here and there to grasp, that the most economical life of a lamp was ended long before it ceased to give out light, the economical life being the shorter the dearer the electric power and the cheaper the initial cost of the lamp.

But the characteristic fondness of people to stick to old friends that have served them, which made Frederick the Great buy back one of his old three-cornered beavers at a princely price, and which prevents lesser mortals parting with their hats even when they have acquired the epithet of shockingly bad, renders the public quite oblivious to the fact that the curve of the total cost of a candle-hour has a minimum ordinate at some comparatively short number of hours. If the lamp breaks he will replace it, if it becomes too dull for his needs he will grumble at the fickleness of electricity and buy another lamp, but that a particular time should be called the "smashing point," as if at that point he had to remove an apparently good lamp from its socket, and to put his foot on it, was really too theoretical and ludicrous, thought the economical householder.

Some eighteen months ago I suggested in lectures to my students that the difficulty might be overcome by the establishment of an agency to buy up lamps which had been run for three or four hundred hours at places where electric power was dear, for example, at watering places on the south coast, and to sell them to places where power was cheap, as at Newcastle. "Taking coals to Newcastle" has long been a proverbial expression of folly, but taking half-used lamps to Newcastle, had the price remained at 3s. 9d., might have become a trade showing wisdom, for buying for 2s. a 3s. 9d. lamp that had been run for, say, 300 hours at Eastbourne where power used to be over a 1s. a Board of Trade unit, and selling it for 2s. 6d. at Newcastle, where power was 4½d., would have been a profitable transaction for both seller, buyer, and agent.

Subsequently another solution of the difficulty occurred to me, and one that might lead possibly to even greater economy than could ever be obtained by discarding lamps at the proper time when they were run with the normal potential difference—and that was to use a higher potential difference. For then the lamp would dull sooner and the user would discard it without reference to curves. If, then, a potential difference could be experimentally found, such that the useful life of the lamp at that potential difference was even greater than the strictly economical life when the normal potential difference were used, two ends would be attained.

Therefore, more than a year ago arrangements were commenced at the Central Institution to make daily measurements of the light and current when various groups of lamps, all identically the same at the start, were run with certain absolutely constant potential differences; and some months back, when the different automatic regulating and recording apparatus had been constructed and got to work in a satisfactory fashion, three sets of 100-volt Ediswan lamps were started, running at 100, 102, and 104 volts respectively, the potential difference being automatically kept constant at each of these values, with no greater variation at any time than a very small fraction of a volt. Very interesting results have been obtained, such as the *very considerable increase* in the light given out by each set of lamps, and the marked *diminution* in the watts per candle during the first 100 hours of running, a phenomena known doubtless by the makers to occur with the modern Ediswan lamps supplied us for this investigation, but I think unknown generally to the users of glow lamps. In fact the construction of the modern lamp has been so modified that the small hump which has been noticed to occur after many hundred hours of running in the life curve of lamps, whose filaments were made of bamboo and flashed by the wet process, has been much magnified, and made to occur in the beginning of the life curve.

The details of these results and the bearing the curves we are obtaining have in deciding the most economical potential difference to be employed for different prices of power, will be published in due course, but, as the price of Ediswan lamps was dropped on Thursday last from 3s. 9d. to 1s. 9d. per lamp, it is important to at once point out that higher voltages than hitherto used must in future be employed to obtain maximum economy with glow-lamp lighting.

For let us suppose that electric energy is supplied at 6d. a unit—this is, of course, much lower than private houses pay in many districts of London—and let us suppose that a 100-volt 8-candle lamp when supplied with 100 volts will give an average of 7½ candles for 600 hours with an expenditure of 42 watts. This is a very favourable estimate of the behaviour of a lamp running for 600 hours, but I take this favourable case and the low price for power in order to emphasise the fact that even under these conditions 100 volts is not the proper potential difference to use with a 100-volt lamp. Then the candle-hours produced will be 4,500, the watt-hours expended 25,200, the value of this energy 151d., the cost of the lamp 21d.; and, therefore, the cost of 100 candle-hours will be 3·82d.

Next let us suppose that the same lamp is run at 104 volts, then since the light, as has been shown, varies as the seventh power of the potential difference* the light of this 8-candle lamp will be over 11 candles. Say that this lamp will give at the 104 volts an average of 10½ candles for 200 hours, with an expenditure of 44 watts. This my tests show is understating the value of the lamp so used. In 600 hours three lamps will be employed, at a cost of 63d., as the lamp is renewed after 200 hours; the lamp hours will be 6,300; the watt hours 26,400; the cost of the energy and the three lamps together 221·3d.;

* "The Most Economical Potential Difference to be used with Incandescent Lamps."

* *The Electrician*, July 15th, 1892.

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and the cost of 100 lamp hours 3·51d., or about 9 per cent. less than before. Actually the saving of using 104 volts instead of 100 will be distinctly greater, for I have intentionally over-valued the running of the lamp at 100 volts and under-valued its running at 104 volts.

Next let us consider places like Eastbourne, Hastings, and Northampton, where electric energy now costs 9d. a unit; then with the same conditions as before we find that when a potential difference of 100 volts is employed the cost of the energy for 600 hours will be 226·8d., the total cost, including the one lamp 247·8d., and the cost of 100 candle hours 5·5d. Whereas when a pressure of 104 volts is maintained, and three lamps are used in the 600 hours, the cost of the energy becomes 237·6d., the total cost including the three lamps 300·6d., and the cost of 100 lamp hours 4·78d., representing a saving of over 13 per cent. And as explained before, the actual saving obtained by using 104 volts will be considerably greater than this.

Indeed, if we even assume that the lamp run at 104 volts, and giving 10½ candles, is replaced every 150 hours, while the one run at 100 volts is supposed to produce an average of 7½ candles for 600 hours, the total cost of 100 lamp hours in the former case only comes out as 5·1d., or about 10 per cent. less than in the latter. This reasoning becomes even more forcible in the case of 16-c.p. lamps, since the cost of a lamp is the same, 21d., while the expenditure of power per lamp is increased from 42 to 64 watts, so that the cost of lamp renewals form a less fraction in the total cost of lighting. Hence, *a fortiori*, a pressure of 104 volts is more economical to use with 16 candle 100 volt lamps than 100 volts.

Clearly, then, higher pressures must be employed for lamps than formerly, especially in 8d. or 9d. districts; or, as a householder cannot alter the potential difference supplied to him, he ought, when purchasing new lamps, to order those marked for a lower pressure than the stated pressure furnished him by the supply company. Exactly how much lower should be the marking of the lamp to obtain maximum economy for each value of the Board of Trade unit I shall not be able to state until the experiments being carried on in my laboratories are completed; but for a house provided with 100 volts, direct current like my own—which means, as seen from the recording voltmeter, that the Company, greatly I think to their credit, furnishes a nearly constant pressure of 101 volts during the 24 hours—I shall provisionally recommend the use of lamps marked not higher than 97 volts. And, assuming that the amount of light previously obtained was sufficient, then these 97-volt lamps might be chosen of 6½ c.-p. and 13 c.p. to give, respectively, about 8 and 16 candles when run at 101 volts.

The increased brightness of the filament will lead to no practical difficulty, since those who might object to this have already clothed their incandescent lamps in such thick coats that the poor lamps can do little more than keep themselves warm. The higher efficiency at which the lamps will be run will cause less heat to be generated for a given amount of light, a change that probably few will object to.

Many rosy comparisons have been made by electrical engineers of the cost of lighting by electricity and by gas. From the results, however, of a very extensive and accurate series of tests made in my laboratory, about a year ago, on the cost of lighting with a great variety of gas burners, governed and ungoverned, for each different gas pressures varying slowly in some cases from ⅛in. to 3in. of water, I am able to give a comparison which I trust has no bias either on the electrical or on the gaseous side.

Of all the burners my students tested the best governed was the 8-candle Bray's burner for street lighting. With that burner the cost per 100 candle-hours did not sensibly vary for any pressure of gas from ½in. to 3in. of water; and cost, with gas at 3s. a thousand cubic feet, 1·82d. A very good burner was Sugg's 16-candle No. 5 table-top governed. The governing for varying gas pressure we did not find as perfect as with the previous burner mentioned; but at a pressure of about $1\frac{1}{10}$in. of water, where we found the economy greatest and the light exactly 16 candles, the price of 100 candle-hours was only 1·29d. Leaving on one side our tests on large gas burners like the Wenham, which do not, of course, give a light comparable with that of an 8 or 16-candle glow-lamp, and our tests on various Welsbach mantle lamps, whose life histories I shall describe on another occasion, the most economical gas burner we tried was a Sugg's No. 1 London Argand. At a pressure of $1\frac{2}{10}$in. of water that burner gave a light of 22½ candles with a cost per 100 candle-hours of only 1·03d., gas, as before, being taken at 3s. per 1,000 cubic feet, but no allowance being made for the renewal of lamp chimneys, an item of expenditure that can, however, be rendered very small with care.

Let us compare with these prices the cost of using a 100-volt 16 candle lamp, at 104 volts, and renewing it after every 200 hours. The average light we may take at 21 candles, the watts at 66; hence, if we take 4d. per Board of Trade unit, the cost of energy in 200 hours will be 52·8d., the cost of the lamp 21d., the total cost 73·8d., the candle-hours 4,200, therefore the cost per 100 candle-hours will be 1·76d.

The price is less than the cost of lighting with the Bray's street-lamp-governed burner, referred to above, and, of course, much less than the cost of lighting with cheap ungoverned burners, where the cost of 100 candle-hours may easily reach 3d., or more, but it is not as cheap as using Sugg's governed table-top burners, nor is it nearly as cheap as using Sugg's London Argand burners if the pressure with the latter be not allowed to fall below about $\frac{7}{10}$ths of an inch.

In this article I have considered only the effect produced by the reduction of the price of English lamps to 1s. 9d., and I have not dealt with the result of the introduction of foreign lamps at probably lower prices. The Westinghouse stopper lamp sells in bulb, for example, in America, for 1s. 1d., and if the lamp be returned with only the filament broken 5d. is given back, so that the actual cost to the large consumer is only 5d., or not much more than one-third of even the price to which English lamps were reduced last week. The life history of the Westinghouse stopper lamp, and of all the other important American types when run at their normal pressures will be known to the world before the end of the year; for prior to my departure from Chicago we had started, mainly through the energy of Prof. Thomas, tests of about 1,000 specimens of glow-lamps on a basis which many interviews with representatives from the various lamp companies had secured general acceptance.

ON A NEW FORM OF VARIABLE POWER-GEAR FOR ELECTRIC RAILWAYS AND TRAMWAYS.*

BY W. WORBY BEAUMONT.

It is a matter of great importance on electrical railways and tramways that the maximum steam-engine power at work in the generating stations should be as little above the mean load as possible. It is found on electrical railways now at work that there is a great waste of power, and therefore of fuel, in consequence of the large consumption of current in getting the trains into motion by motors attached directly to the axles. On the South London Railway it is found that the power employed electrically in over coming the inertia of the train is from 25 to 50 and 60 per cent. greater than that required to keep the train going.

Mr. J. H. Greathead, M.I.C.E., the engineer of this railway, has shown that if this could be avoided from 20 to 30 per cent. of the engine power which must under present conditions be kept running might be shut down. The author showed this by diagrams representing the variation in the consumption of power in the working of this railway, as given by Mr. Greathead.† For several reasons the employment of geared locomotives is undesirable on railways, although single-reduction gearing is most generally adopted for tramways, and probably will remain best for that purpose. The noise made by high-speed gearing and the wear are both objectionable, otherwise a geared locomotive offers the means of overcoming, to some extent, the losses referred to.

In the Paper the author showed how an intermediate course could be adopted which would remove the loss of power at the generating station. The electric motor is placed directly on

* Paper read before the British Association in Section G.

† *Proc.* Inst.C.E., Vol. CXII.

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the driving-axle, but is reduced in size and power to more nearly that of the mean horse-power required on the road. This, for the greater part of the journey of a train from station to station, drives the axle upon which it is placed, at its own speed, just as those do which are now upon the South London Railway. The motor is, however, on a hollow spindle, which drives the axle, when starting a train, through the medium of a compact double clutch containing one pair of epicycloidal reducing wheels. The clutches are operated by electro-magnets in one case, and by fluid pressure in another.

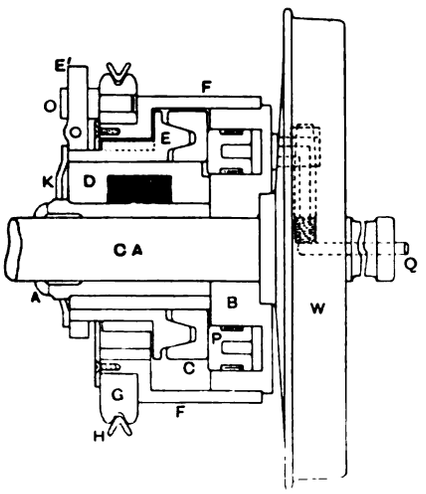

FIG. 1.

In Fig. 1 the gearing is shown as operated by fluid pressure, and arranged as for a locomotive for direct driving. On the axle C A is fixed a disc B, containing an annular "cylinder," or rather chamber, in which is an annular piston, P, which, by admission of oil, under pressure, or air from the continuous-brake cylinders, is caused to press, when necessary, against the gripping ring C. On the end of the motor shaft A is fixed an eccentric, D, which gives a gyrating motion to the toothed ring

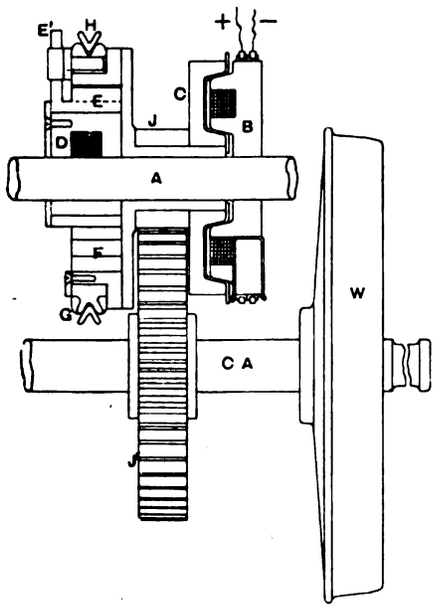

FIG. 3.

E. This correspondingly gives motion at a slow rate to the gear ring F, which is fixed to the disc B. Upon a projecting part of the internal gear ring is a bridle with an arm, E'. This arm is free to slide in a bridle, O, pivoted in a ring, G. The ring G is either permitted to run free or is held fast by parts which constitute a brake clutch, of which only the ring H and levers L are seen.

When it is desired to start a train the ring G is held fast by this apparatus, and O becomes a fulcrum, about which E' with the ring E gyrates. The locomotive axle is then driven by the wheel or ring F at one-fifth the speed of the motor, or a power ratio of five to one. This is required for a few seconds at each start. The inertia of the rest of the train having been overcome, the ring G is set free, and fluid under pressure admitted at Q, thus pressing the ring C upon E. This fixes the whole of the working parts of the gear, and couples the motor shaft and locomotive axle, so that the latter is direct-driven. The motor can thus run idle, driving nothing, or it may drive the axle at one-fifth of its speed, or at its own speed. When running at normal speed the whole of the gear described runs as one solid

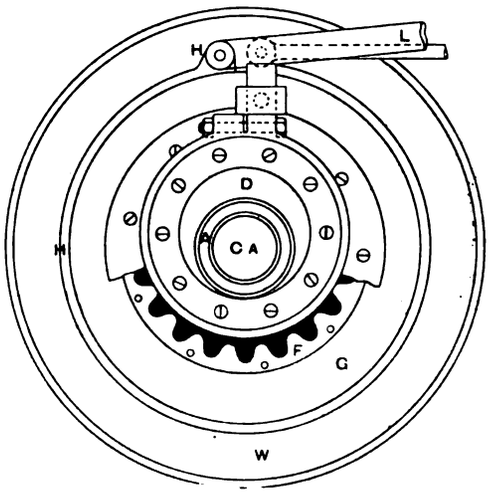

FIG. 2.

piece, and only works for starting a train or getting up-hill. A breakdown would leave the locomotive in the condition of a gearless engine.

The arrangement of the gearing for tramcars, when single reduction gear is employed, is shown in Figs. 3 and 4. In this the motor shaft A carries a disc electromagnet, B, which has as an armature a disc, C, on the boss of the pinion J, which gears into the wheel J' on the car axle, the ratio being four

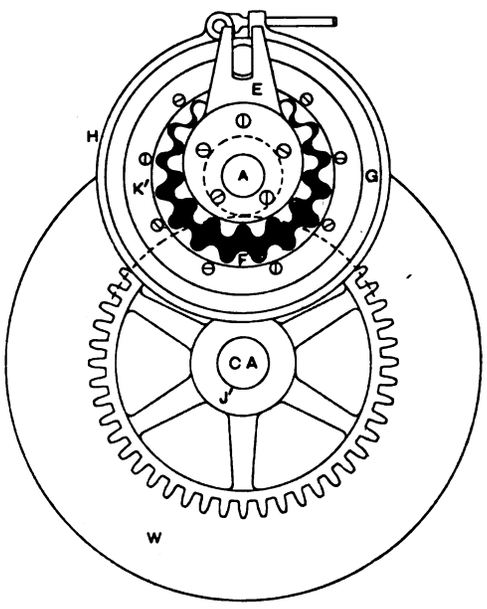

FIG. 4.

to one. The epicycloidal gearing is very similar to that in Figs. 1 and 2, and gives, as shown, a speed ratio of five to one. With this arrangement a motor of 15 H.P. would be ample for any tramcar, instead of the 30 H.P. now used. The motor in starting may run idle, or may drive the car axle through the epicycloidal gear and single reduction gear at, say, a ratio of twenty to one, or by passing a current into the coils and by energising the magnet B, the whole apparatus runs solid on the motor shaft, the gear ratio then being that of the single-reduction gear of four to one.

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AN AIR PUMP, WHICH CAN BE WORKED EITHER AUTOMATICALLY OR BY HAND, IN WHICH THE WORKING FLUID MAY BE SULPHURIC ACID, MERCURY, OR ANY LIQUID HAVING A SMALL VAPOUR PRESSURE.*

BY J. J. THOMSON, PROFESSOR OF EXPERIMENTAL PHYSICS, CAMBRIDGE.

In some experiments on the discharge of electricity through gases I had occasion to prepare tubes which should be free from mercury vapour. The safest way of doing this seemed to me to be to get rid of the mercury in the pump. I accordingly fitted up a pump in which the mercury was replaced by sulphuric acid.

As the arrangement adopted for this pump readily admits of its being made automatic, and as sulphuric acid has the advantage of being very much cheaper than mercury, it seems possible that the pump may be convenient for other purposes than the one for which it was designed.

Any fluid which has very little vapour pressure can be used in this pump; mercury can be used in this just as well as in the ordinary form of pump. The arrangement of the pump is represented in the diagram. The vessel to be exhausted is attached by an air-tight connection to A. The end B is attached to a three-way tap, so arranged that when it is turned one way B is open to the atmosphere through a fine nozzle T, while when the tap is turned another way, B is connected to a water pump or other convenient means of producing a fairly low pressure. The extremity K is also connected with this pump.

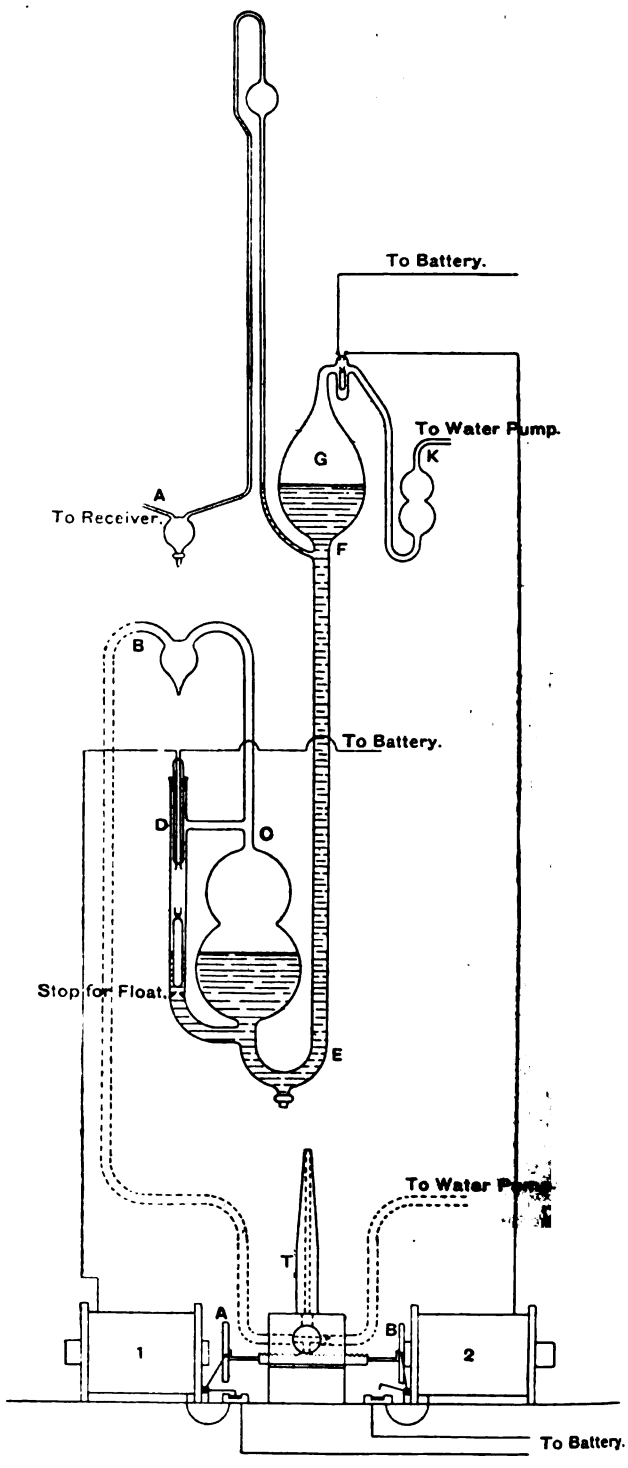
I will first describe the method of using this pump when worked by hand.

The air is partially exhausted by means of the water pump. To do this the three-way tap is turned so as to cut off the communication between C and both the atmosphere and the water pump. The air is removed through K by the water pump, the air from above the acid in C bubbling up through the acid in the tube *ef*, and escaping through K. When a fair vacuum has been got in this way the three-way tap is turned so as to connect C with the atmosphere. The pressure of the air on the top of the acid forces the acid up the tube EF into the bulb G, which it fills, driving the air before it out through K, whence it is carried away by the water pump. When the acid begins to flow over the bend K, the three-way tap is turned so as to put C in communication with the water pump; this reduces the pressure in C, and the acid flows back and falls below F, when more air rushes from the tube to be exhausted into the bulb. The three-way tap is then turned so as to put B in communication with the atmosphere, when the acid again rushes up into the bulb driving the air before it.

By repeating this process the amount of air in the bulb to be exhausted is continually reduced. It will be seen from the preceding description that all the experimenter has to do is to turn the three-way tap at the proper time, the rest of the work is done by the water pump.

To make the pump automatic, all that is necessary is to use some mechanical arrangement by which the pump itself can turn the tap at the right instant. This can be done by fixing to the three-way tap a handle to which two pieces of iron are attached. Two electromagnets (1 and 2) are placed near these pieces of iron in such a way that when 1 is excited the piece of iron is attracted to its core, and the handle of the tap turned so as to put B in communication with the atmosphere, while when the electromagnet (2) is excited the piece of iron B is attracted and the handle of the tap pulled over so as to put B in communication with the water pump.

The electromagnets are in series with a battery, and with connections in the pump, which are so arranged that when the acid rises to a certain level in C the circuit of the electro-magnet (1) is completed, and when the acid sinks below this level the circuit is broken; while when the acid rises to a certain point in G the circuit 2 is completed, while when the acid sinks below the level this circuit is broken. The arrangement shown in the diagram and in the models for making these connections consists of two floats, carrying at their top a conductor which connects two pairs of wires fused into the pump at D and H respectively.



I have much pleasure in thanking Mr. Everett and Mr. Pye, of the Cavendish Laboratory, for the skill they have shown in the construction of these pumps, as well as for many suggestions they have made for the improvement of some of the details.

* Paper read before the British Association in Section A, Nottingham, September, 1893.

The Destruction of Telegraph Insulators.—In connection with a recent case of telegraph insulator destruction, it is worth noting that the amusement of breaking insulators is growing in public favour. In 1887 the number of insulators broken was 11,479; in 1888, 11,802; in 1889, 12,847; and in the first half of 1890, 8,270.

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The engines and dynamos are, as usual, in German stations, slow-speed triple expansion, condensing, and direct-coupled machines, each engine running two dynamos, an arrangement which must be disadvantageous, one would suppose, at light loads. The dynamos have the commutator arranged as part of the armature winding, the armature being wheel-shaped, and the brushes running on the periphery, and are, of course, multipolar.

The greatest amount of interest attaches to the scheme of connections, which is broadly as follows:—The current from each dynamo, after passing through fuses, ammeter, automatic cut-out, and indicator to a double-pole two-way switch, by means of which it is led either to the charging contact of the cells or to the corresponding omnibus bar. Eight relays lock the switches for switching in a dynamo, until it reaches the proper voltage. The discharge switches are similarly connected to the five distributing bars, to which the feeders are also coupled. A concrete conduit is used, in which are fixed insulators carried on an iron frame, and so arranged that the conductors are 4in. apart. The copper connections are made by tinning the ends, which overlap about 6in., and inserting two bolts, alteration in length being taken up by S pieces at intervals. Manholes are provided at the feeding points, and the connections are arranged circularly. House connections are made by ordinary armoured cables. The manholes at the feeding points are put so low in the conduit that any water running in must flow into them; and facilities are provided for pumping it out. The conduits are thoroughly ventilated by means of special pipes, and have acted perfectly, in spite of very unfavourable circumstances as regards water, and so on, and no failure of insulation has been reported during nearly three years' working. The conductors are designed for 60,000 lamps at a time, while the present plant can only run 16,000, of which 12,000 by the dynamos alone. The total length of the system is eight miles, and the average distance from the station two-thirds of a mile.

The running of the Königsberg station up to date has shown that the five-wire system is not so complicated in regulation and distribution as has been supposed; on the contrary, its utility has been satisfactorily demonstrated; while the advantages of combining the conduit and five-wire systems are great from the point of view of cheapness and efficiency in putting down the mains.

So much is this the case that, although the mains are laid for more than four times the present number of lamps, the financial results have been throughout perfectly satisfactory.

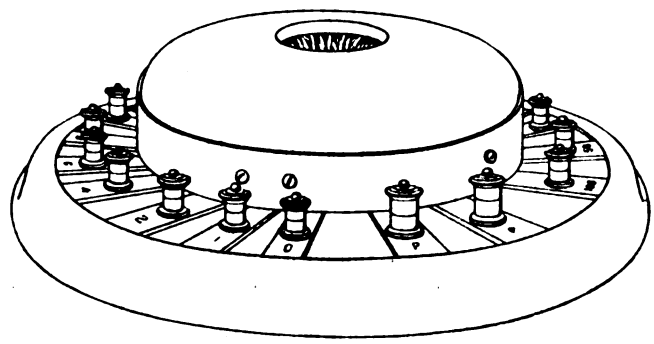
THE ELECTRIC LIGHTING OF CASSEL.*

This work is worthy of notice for more than one reason. The waterfall which is used for the service, while on an average more than sufficient to supply the load, does not suffice for the maximum, and it has therefore been found necessary to store the energy by means of accumulators; while the distance of the source of power from the town has made it necessary to use alternate-current transmission, and direct alternate-current transformation. The falls of the Fulda, at Neumühle, about four miles from the town, are utilised to drive four 50 H.P. turbines, transmitting by bevel gear to the main shafting, which drives by means of gearing two 100 H.P. Kapp-Oerlikon dynamos. An absorption regulator is provided in order to keep the speed constant. Two engines are in reserve in case of accident. The dynamos transmit at 2,200 volts to the two stations in the town, where alternate-current motors, each directly coupled to two direct-current machines, supply the necessary power for the town lighting. These motors are similar in size and construction to the generators, but have no exciters, being excited from the direct-current dynamos. The accumulators run in parallel with the dynamos by means of the usual "charge and discharge" switches, and the remainder of the system calls for no remark. The starting of the motor may be noticed, which is performed in the following manner:—The dynamo is started at Neumühle, and the motor at Cassel, by means of the accumulators, using the direct-current dynamo as a motor. The alternator is then excited, and got into phase in the usual manner, and then switched on. The direct-current dynamos are then coupled to the omnibus bars and the load properly adjusted, the whole proceeding taking only two or three minutes. The efficiency of the system of transmission is 71 per cent., and the total efficiency 55 per cent. The plant has recently had to be increased by addition of more accumulators, and about 10,000 30-watt lamps are now on the mains, and any further increase will necessitate another addition to the plant. The capital expenditure on this work has amounted to about £38 800. The receipts for the nine months, July, 1, 1891, to March 31, 1892, amounted to about £3,500; and the expenditure for works, costs, salaries, &c., was about £1,700; and for interest and depreciation, £1,100; a total of £2,800. The balance added to the amount allowed for depreciation makes about £1,000 towards a sinking fund for repayment of capital. The tariff was from 11d. to 8d. per Board of Trade unit, an average price in Germany, and has been reduced to an average of 9d. The works have been running continuously since July 1, 1891, and were designed by Herr Oscar von Miller.

* Abstracted from the *Elektrotechnische Zeitschrift*, August 4, 1893.

A SUB-DIVIDED TRANSFORMER.

The small sub-divided transformer, illustrated herewith, has been designed by Messrs. Miller and Woods, of 2, Gray's Inn-road, for lighting up lamps of various voltages, or working medical cauteries, &c., from the alternating-current street mains. It is of the ordinary ring type, and has an output of about 300 watts. On 100-volt circuits almost any voltage between 1 volt and 200 volts can be obtained, and on a 50-volt supply anything between 1 and 100 volts. For instance, a lamp of 2 volts can be lit between terminals



Miller and Wood's Sub-divided Transformer.

0 and 2, one of 3 volts between 1 and 4, and one of 70 volts between 30 and 100. For obtaining 101 volts and upward to 200, the primary circuit, or rather the street main, is put in series with the secondary (which can be done owing to their phases being opposed) by means of a piece of fuse wire connected between the primary terminal P and the secondary O. Any portion of the secondary may also be connected so as to oppose the primary. The transformer itself, which is about 5½in. in diameter, is mounted on a piece of slate, and all the connections are on the surface.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 15, 1893.

Business Depression.—The extreme business depression that has existed in the United States for several months seems to have passed the acute stage, but the prospects for an immediate revival are not particularly bright. The electrical industries have stood the strain remarkably well, but some of the weaker firms have succumbed, notwithstanding the consideration to creditors shown by the stronger members in the electrical trades. The General Electric Company has suffered severely in the stock market, one result of which has been great reductions of *personnel* in its elaborately organised departments, and a greater concentration in its manufacturing branches.

The Fort Wayne Electric Company.—One of the important electrical companies absorbed by the Thomson-Houston Company previous to the formation of the General Electric Company was the Fort Wayne Electric Company, which had acquired a very profitable share of the arc lighting business in the United States. A rumour is now afloat that this Company has separated from the General Electric and will hereafter conduct business as a competitor.

The American Institute of Electrical Engineers.—The subject of establishing branches of the Institute in various parts of the United States is being discussed. The argument is that the number of members will be largely increased as well as the number of Papers read. While the former result is considered desirable, many of the members are of the opinion that the increase in Papers would be in quantity rather than in quality, and the proposed measure will therefore meet with much opposition unless the published proceedings of the branches are confined to discussion of Papers read before the main body of the Institute.

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The Westinghouse Charges.—In the suit of the Westinghouse Electric and Manufacturing Company against the *employés* of the General Electric Company for theft of plans, blue prints, data, &c., the jury failed to agree, and the suit will be re-tried. Almost the entire case of the Westinghouse Company rested on the testimony of the draughtsman who committed the theft; the jury was charged that unless his testimony was corroborated a verdict of guilty could not be returned, and as several witnesses testified to his bad character the result may be attributed to these considerations rather than to the testimony of the defence.

CORRESPONDENCE.

PAPERS FOR THE B.A.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I note your remarks in this week's *Electrician* on the dearth of new matter presented to the British Association at the meeting which has just been held.

As I was not able to be present I cannot judge whether your remarks are justified, though I should say that two of the Papers, at least—Mr. Kapp's and Mr. Snell's—contain information useful to those for whom they were written.

I would seriously ask, however, whether the conditions to which authors of Papers have to submit are such as are calculated to inspire busy men with much enthusiasm for work of this kind. The Section meets at 11 a.m. The writer of the first Paper on the list, usually some eminent man, is sometimes allowed to read his Paper without interruption, sometimes he is not. Speakers on that and all subsequent Papers are repeatedly warned that the time is limited and there are a number of Papers to be read.

Writers of succeeding Papers are asked to condense, and are usually interrupted repeatedly, speakers on them being subject to greater and greater pressure, till at about the fourth Paper—sometimes earlier—the author finds that his audience consists of a certain number of chairs, *plus* a few listeners, while the authors of the fifth, sixth, and seventh Papers are requested to have their Papers taken as read.

It is well known that three hours is as long as any audience can be kept for one subject. Why not let the meetings be for three hours, and accept only the number of Papers that can be read and properly discussed in the time?

If an author, when advised that his Paper will not be likely to come on, elects still to have it put down for reading, no harm is done; but it is surely not far removed from an insult to ask a busy man—and it is the busy men whose Papers are usually of most value—to prepare a Paper to which no one will listen.

If a Paper, too, is to be of value, no matter how eminent or experienced the author may be, surely it is after it has undergone the ordeal of discussion by those who are competent to criticise it in detail.—Yours, &c., SYDNEY F. WALKER.

[Mr. Walker takes the British Association too seriously. He was at great trouble, we remember, with a Paper at Leeds, illustrated by experiments on a large scale. His efforts were sadly wasted. As a lecture before a local scientific society it would have been a great success. This was before Section G, which is quite a holiday gathering.—ED. *E.*]

GLOW-LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If any of your readers will be kind enough to afford me some information on the following points I shall be greatly obliged, and I have no doubt the answers will be of service to others as well as myself.

I suppose it may be taken that the ordinary 100-volt 16-c.p. lamp, when consuming 60 watts, will last about 1,000 to 1,500 hours, say 1,200 hours on the average. What will its life be if run at 105 volts, and is there any proved relation between watts per candle-power and life?

Further, in the case mentioned, will the total watts consumed by the lamp increase in the ratio of 100 to 105, or 63, or will the current increase also, and if so, how much?

Thanking you in anticipation for inserting these queries,—Yours, &c., T. W. WALLIS.

London, September 27, 1893.

[No complete tests of well-known lamps as to the relation between watts and life have been published. The second question is answered in Prof. Ayrton's article on p. 585 of our present issue.—Ed. *E.*]

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published s compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

September 11, 1893.

17,025. T. B. SHARP. Birmingham. Improvements in raising and lowering the light of electric glow-lamps.

17,030. G. ST. JOHN DAY and W. H. WHEELER. Manchester. Improvements in apparatus for facilitating the erection or fastening of electrical conductors in wood casings.

17,045. J. H. GASH and J. SKILBECK. London. Improvements in, or relating to, electric clocks, part of such invention being also applicable for other purposes.

17,052. W. J. DAVEY. London. Improvements in arc electric lamps.

September 12, 1893.

17,093. T. SLOPER. Devizes. Improvements in, or relating to, electric telephones.

17,127. T. CRANEY. London. Improvements in electrolytic cells.*

September 13, 1893.

17,172. S. W. BAYNES. Bradford. Improvements in air and water-tight covers for junction boxes used in electrical distribution, and for other purposes.

17,175. T. SLOPER. Devizes. Improvements in, or relating to, electric telephones an dmicrophones.

17,189. J. M. M. MUNRO and J. MCFARLANE. Glasgow. Improvements in electric switches.

17,197. R. E. B. CROMPTON and S. L.'BRUNTON. London. Improvements in dynamo-electric machinery.

17,220. C. A. J. H. SCHRODER and H. E. R. SCHRODER. London. Improved methods of recovering zinc from the waste products of galvanic batteries.*

17,221. C A. J. H. SCHRODER and H. E. R. SCHRODER. London. New or improved galvanic batteries.*

17,234. A. A. GOLDSTON. London. Improvements in electric switches for series circuits.

September 14, 1893.

17,310. SIEMENS BROS. AND CO. (LIMITED). London. Improvements in contact apparatus for receiving currents from overhead conductors on electric railways. (Messrs. Siemens and Halske, Germany.)

17,330. J. W. EDMUNDSON and F. J. SATCHWELL. London. Improvements in holders for incandescent electric lamps.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

15,318. LEIGH (Apollonj). Electrical transformers.

15,425. WRIGHT. Burglar detector fire alarm and police call.

15,437. GRAY and PRICE. Electrical contacts.

15,689. WILLOT. Relays for electric telegraphs.

16,315. BOWEN. Electric telegraphs.

16,768. PIPPETTE. Switching telephone, &c., exchanges.

17,092. CROMPTON and DOWSING. Insulating and supporting electric wires.

17,093. AYRTON and MATHER. Electrostatic measuring instruments.

18,357. WYAND and SCHRAMM. Electrical switches.

18,847. JOEL. Field-magnets and armatures of current electromotors, &c.

18,994. TIMMIS. Electromagnets.

1893.

206. SALOMONS and PYKE. Producing light by alternating electric currents.

2,331. EDGERTON. Secondary batteries.

5,987. FLETCHER. Telephone, &c., circuits.

9,262. ERICSSON. Electric meters.

7,848. LEVI. Indicating telegraphic messages.

13,066. BOULT (Stever). Electric incandescent lamps.

13,911. THOMSON (Coffin). Heating, &c., metals electrically.

14,076. LAKE (Armen). Electric measuring instruments.

14,210. SIEMENS BROS. AND CO. (LIMITED). Telegraph posts, &c.

14,474. FORBES. Telephone circuits.

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TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

COMPETITION.—The Morley Corporation announce in our advertisement columns that they are prepared to receive particulars of schemes for the lighting of the town hall and the borough generally. The scheme selected as the most suitable is to be awarded a premium of £100. Conditions of the competition may be obtained on application to Mr. R. Borrough Hopkins, town clerk, and plans and particulars are to be sent in before December 1st.

TENDERS INVITED.—The Royal Company of Portuguese Railways (Lisbon) invite tenders for the installation of the electric light in the Lisbon Station and the Rocio tunnel. Conditions are to be obtained from the Administraca de Companhia real dos caminhos de ferro Portuguezes, Lisbon.

TENDERS ACCEPTED.—The tender of Mr. Willway has been accepted for an electric light installation at St. Peter's Hospital, at Bristol, at £28. 9s. 6d.

——— The Bradford Corporation have accepted the tender of Messrs. Siemens Bros. and Co. (Limited) for the supply of switchboards for their central station.

——— The tender of Messrs. W. Burrow and Son, of Bolton, has been accepted by the Corporation for the erection of the electric lighting station in Spa-road.

APPOINTMENT VACANT.—The Directors of the Scottish House-to-House Electricity Company (Limited) announce in our advertisement columns that they are prepared to receive applications for the post of manager of their new generating station at Coatbridge. Applications to be made by letter only to the Secretary of the Company, 109, Hope-street, Glasgow.

APPOINTMENT.—Mr. T. H. Aldridge has obtained an appointment with the Grand Junction Canal Works at their pumping station at Tring.

DISSOLUTION OF PARTNERSHIP.—Messrs. Newton and Savage, 6 and 7, Tysoe-street, Clerkenwell, E.C., electricians, have dissolved partnership. Debts will be paid by G. C. Savage.

REMOVAL NOTICES.—The Manchester Edison-Swan Company (Limited) notify us that they have removed their offices from 14, St. Ann's-square to Temple-chambers, 29, Brazennose-street, Manchester.——The address of Messrs. Hughes and Lancaster is now Albany Buildings, 47, Victoria-street, Westminster, S.W.

LIQUIDATIONS.—A petition was presented on the 19th inst. by Gen. Sir R. J. Meade for the winding up of Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited), and is down for hearing at the Royal Courts of Justice, Strand, on October 4th.

——— The shareholders of the British Gas Engine and Engineering Company (Limited) have decided to voluntarily wind up the Company, and have appointed Mr. W. S. Mackenzie liquidator.

——— Claims against the estate of the Thorneburry Miners' Safety Lamp Company (Limited) must be sent in to the liquidator, Mr. F. Newton, 9, Warrington-crescent, Maida Vale, by October 21st.

BANKRUPTCY.—A meeting of the creditors of Selina Rowbottom, electrical engineer, of 32, Abbey-street, Derby, carrying on business as S. Rowbottom and Co., was held at Derby last week. The debtor's statement showed liabilities £302. 19s., of which £280. 4s. was expected to rank for dividend. The stock-in-trade, which cost £400, was estimated to realise £250, the machinery £36, trade fittings, &c., £25, furniture £20, and there were good book debts put down at £26. 10s. The alleged cause of failure was bad trade during the past year. The Official Receiver's observations were that the debtor was the wife of Samuel Rowbottom, who was adjudged bankrupt on April 24, 1889, and had not obtained his discharge. His effects were sold by auction, after which Mrs. Rowbottom at once commenced business under the style of "S. Rowbottom and Co.," as she says, without capital. In August last the debtor gave a bill of sale to a creditor, with the result that she was pressed by others, and an execution having been levied on her goods, she filed her petition. It appeared to him that the bill of sale was invalid, and the debtor had so treated it in her statement. The usual resolutions were passed.

ELECTRIC TREATMENT OF SEWAGE.—The Hermite process for the disinfection of sewage by means of electrolysed sea water is, we understand, being tested by Messrs. Merryweather and Sons, of London, with a view to its application to the drainage of seaside towns. The process, which was described in *The Electrician* at the time of its publication, consists in the use of electrolytically-treated sea-water for flushing the sewers.

INCANDESCENT LAMPS.—We learn that the General Electric Company (Limited) have acquired the incandescent electric lamp works built by the Brush Electrical Engineering Company at Brook-green, Hammersmith, for the purpose of manufacturing incandescent lamps. We understand that the plant now installed and being erected is capable of an output of over one million lamps per annum. The management will be in the hands of Mr. C. J. Robertson, well known as one of the most experienced incandescent lamp makers in England and on the Continent.

——— The Brush Electrical Engineering Company announce in our advertisement columns that they will resume the sale of their glow-lamps in the United Kingdom on and after November 10th. The lamps are manufactured at the Company's own works, and are made under the most modern and improved processes.

MESSRS. HARPER'S WORKS, ABERDEEN.—We are requested to state that the electric installation at these works was designed and constructed by the General Electric Power and Traction Company (Limited), Kentish Town, London.

PORTABLE BATTERIES.—The Edison and Swan United Electric Light Company have issued an illustrated price list of portable secondary batteries of various sizes. Resistance lamps for charging are offered, and full directions for use are given.

ABERYSTWITH.—The Town Council at their meeting last week adopted a recommendation of a committee meeting of the whole of the Council to transfer the powers, &c., obtained under their Provisional Order, to a company or person, with the approval of the Board of Trade, and not to carry out the order themselves. A further recommendation that the order be transferred to the Bourne and Grant Electricity Supply Company (Limited) was discussed, but a decision was deferred until an interview had been held with Messrs. Bourne and Grant, a special meeting of the committee being called for that purpose.

BRUSSELS.—The electric light is to be experimented with on the local railway. It is said that the Schmid type of lamp is to be employed.

CARDIFF.—A complaint was made at a meeting of the Cardiff Lighting and Electrical Committee held last week of the defective lighting of a number of the principal streets by the gas company. The light inspector stated that he had brought the matter before the notice of the company several times, but nothing beneficial had resulted, and it was ultimately resolved that the gas company be communicated with on the subject, and that the sub-committee consider their position with regard to the agreement with the gas company in the matter.

CHAPEL LIGHTING.—The Bayswater Wesleyan Chapel is the first chapel in London belonging to that body which has adopted the electric light. An installation, comprising 73 incandescent lamps, the majority of them 16 c.p., has been carried out by Messrs. Money and Nash, at a cost of £125.

CHIPPENHAM.—The extensive premises of the Wiltshire Bacon Curing Company are lighted throughout by electricity, and the 250-light dynamo being larger than is required by the Company, it has been suggested that, with a small additional outlay, increased power could be procured sufficient to light the town and for private purposes. Some experiments in this direction have been made and have given satisfaction; and it is thought that an arrangement may probably be come to between the Corporation and the Bacon Curing Company for the supply of the current at a reasonable rate.

CITY OF LONDON UNION.—The City of London Board of Guardians have referred to the House Committee to consider and report as to the desirability of lighting the Infirmary at Bow by electricity.

CLERKENWELL.—Mr. Sidney Morse has made another application to the Vestry for an extension of time in which to complete the electric light installation. The Vestry have previously declined to grant the extension, and at their last meeting resolved that they could see no reason at present for altering their decision.

DERBY.—Rapid progress is being made with the Corporation's scheme of street and private lighting by electricity in this town, and the arrangements for the latter are almost completed. There will be two circuits in each street, and every alternate lamp will be placed on one of these circuits so that one half of them can be lighted or extinguished simultaneously. By a switch placed in the pillar each lamp can be extinguished separately. The city is divided into two sections (east and west), and each district has its own distinct and separate circuits and generating machinery. All the city south-east of Shipquay-street and Bishop-street, including the Waterside, will be supplied through its own distinct duplicate circuits from two Siemens constant-current dynamos, and all the city north-west of these streets will be supplied by different circuits from another pair of dynamos. A third or spare set of dynamos are in the station as a stand-by, to be switched on to any circuit in case of accident. These six dynamos are each capable of

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running 60 arc lamps of 2,000 candle-power each, but as two of these will be held in reserve there will be in constant use four capable of running 240 efficiently. The present contract is for 160 lamps The arc lamps are of the Brockie-Pell type. The conductors are armoured and laid directly in the ground. It is estimated that the annual payment now made to the gas company for street lighting will cover the repayments and interest of the loan of £15,000 obtained by the Corporation, and it is estimated that after the loan is paid off the cost of lighting the city by electricity will be only one-third of the cost of lighting it by gas. The generating station has been erected, the boilers are set, the machinery is in course of erection, and Messrs. Siemens Brothers and Co. are engaged laying the underground cables and wiring the lamp pillars, and by the end of next month it is expected that two of the circuits will be lighted, and the other two circuits immediately after; so that all the installation will be completed and working this winter. The Corporation is said to be ready at any moment to undertake the private lighting, provided a sufficient number of the ratepayers intimate their wish to be supplied.

ELECTRIC LIGHTING IN EDINBURGH.—Prof. Kennedy, London, in a report to the Electric Lighting Committee of Edinburgh Town Council, advises that the whole business part of the city, from the Register House to Donaldson's Hospital, and the principal streets and terraces, along with part of the South Side, including Cockburn-street and part of High-street, should be lit. In considering the system to be adopted he has selected two for recommendation, namely, the three-wire system similar to that he has used in Glasgow, and a combined high and low-tension system such as that used by the City of London Company. The total cost in each case, including an allowance of £10,000 for buildings, and including also the arc lighting plant, but not including the cost of land, would be about £80,000. The cost of doubling the capacity of the plant and mains, when this should become necessary, would be about £30,000 in the first case, and about £28,000 in the other. There was thus no practical difference in capital cost between the two systems, and so far as expense went the decision as to which was best in this case must depend on the cost of working them. The working costs for a three-wire system were well known, as many were in operation. The cost of working a combined high and low-tension system could hardly yet be said to be known, as no system of this kind had been at work anywhere for a sufficient length of time. It had, unavoidably, the considerable additional annual expense of the rents of the transformer sub-stations, and the wages of the men employed to attend to them; and including this the lowest estimate which he could make of the difference in cost of production between the two systems was 0·5d. per unit on 680,000 units per annum (the difference might well be much greater). The balance of advantages, therefore, seemed to him very much in favour of the use of a three-wire system for the northern district, and he recommended the adoption of this system. He also recommends a charge of 6d. per unit.

FALMOUTH.—The Town Council have adopted the recommendation of the Lighting Committee to accept the offer of Messrs. Veale and Co. (Limited) to report on the electric lighting of the main streets for the sum of £8.

GOVAN.—At a meeting of the Govan Lunacy Board last week it was reported that to light Hawkhead Asylum by electricity would cost £5,300, and that the yearly working charges would be £269. 5s. No decision, however, has yet been come to respecting the best mode of lighting the building.

HUDDERSFIELD.—The whole of the rooms on the ground-floor of the Technical School have been fitted up with the electric light and on Tuesday week the supply of electricity from the Corporation mains was formally turned on. It is contemplated to extend the installation to the whole of the school.——The Town Council at their last meeting confirmed minutes of the Electric Light Committee recommending the payment of £3,000 on account to the Brush Electrical Engineering Company; that six 18-kilowatt transformers be purchased for the town hall and the sub-stations, at an estimated cost of £56 each; that nine 1,500, nine 3,000, and six 6,000 transformers be purchased from the Electric Construction Company at an estimated cost of £400; and that eighteen switchboards for transformer stations be obtained, at a cost of £7. 5s. 6d. each.

HULL.—At a meeting of the Committee of the Hull Guardian Society held last week, the Corporation's electric light supply came under discussion, and it was stated by several members of the Committee that, in their opinion, there would be a greater demand for the light if the charges were reduced.

KILLARNEY.—At the last meeting of the Board of Governors of the Killarney District Lunatic Asylum a letter was read from the Board of Control, Dublin, stating that the Board of Control had given the matter of the introduction of the electric light into the asylum careful consideration, but they were not at present advised or prepared to sanction the scheme proposed. Some discussion followed the reading of the letter, and the Board of Governors eventually resolved to ask the Board of Control on what grounds the scheme had been rejected by them, as the Board of Governors had on several occasions fully discussed the subject before adopting it.

KINGSWOOD.—Some discussion arose at the meeting of the Local Board last week as to the electric lighting of the district. Complaint was made that the lights were very bad, and the Clerk said that the fault lay with the lamps, but new ones would shortly be introduced.

LEICESTER.—The Town Council have directed the Gas Committee to at once proceed with the arrangements necessary for carrying out the electric lighting scheme adopted by the Council.

LEWISHAM.—The Crystal Palace District Electric Supply Company have forwarded to the Lewisham District Board of Works a list of roads in which their mains are laid, and have inquired whether the Board were prepared to entertain proposals for lighting by electricity the whole or any part of it. The question has been referred to the Works Committee.

MELBOURNE.—In reply to questions, Mr. Alderman C. J. Ham said at the quarterly meeting of the Town Council on August 10th that the sum originally estimated for the lighting of the city was £75,000, but there was also a sum of £125,000 appropriated for electric lighting works out of the loan of 1892. The electric lighting committee judiciously decided to proceed one step at a time, and carry out the system of public lighting first. As far as he could ascertain, the actual cost would not be in excess of the estimates, and the lighting of the public streets would be effected at a cost within £75,000. The sum of £125,000 appropriated was, he said, not available. Councillor Carter remarked that the Corporation evidently intended to spend the ratepayers' money in competing with existing lighting companies. By such competition the Corporation could bring about the ruin of those companies. Surely, he thought, the Corporation should first of all either buy up the companies or deal with them fairly. The Mayor ruled that these remarks had no bearing on the order of the day. He would point out, however, that the subject of private lighting would come up for discussion after the public lighting had been dealt with. The order of the day was adopted.

MONMOUTH.—A special meeting of the Town Council was held on Friday, when a scheme comprising a complete system of drainage, together with the introduction of the electric light for streets and private dwellings, was adopted. The engineer is Mr. C. Nicholson Lailey, of Westminster, and the cost will be about £16,000.

PENRITH.—At the last meeting of the Board of Health a resolution was passed "That the clerk be instructed to take steps to procure a Provisional Order to enable the Board to provide an electric light installation for Penrith."

PETERBOROUGH.—Mr. J. C. Gill, the borough engineer, has prepared a report upon the question of electric lighting for the city. It is proposed to light the central portion of the town, the mains to be extended as required. Mr. Gill estimates the total cost of buildings, engines, dynamos, accumulators, mains, switchboards, and instruments required for making the Peterborough installation complete at £12,500. To earn 5 per cent. per annum upon this capital, and to provide for working expenses, an annual revenue of £1,710 would be required; and Mr. Gill concludes, from inquiries which he has made, that in a few years the works proposed would be earning sufficient profits to be a valuable property.

RUGBY.—During the vacation the Rugby School Electric Lighting Company (Limited) have been engaged in fitting up for electric lighting the different boarding-houses, the school-house, and the whole of the school buildings, with the exception of the art museum and the school chapel. The dynamos will be driven by a 40-H.P. gas-engine, using Dowson's gas. The work has been entrusted to different contractors, and will be completed before the school re-opens. The whole of it has been done under the general supervision of Mr. J. A. McMullen. The installation will embrace upwards of 1,500 lights, Ediswan incandescent lamps being used. The Company is being carried on on the co-operative principle, all the subscribers being consumers and Directors of the Company.

RYDE.—The Electric Lighting Committee have recommended that the Council apply for a Provisional Order enabling them to supply electric light in their district, and that they obtain powers to borrow the necessary amount.

SOUTHAMPTON.—The electric cranes on the Town Quay formed the subject of a short discussion at the meeting of the Town Council last week. The Works Committee reported that Messrs. Statter and Co. had offered to supply some spare parts of the cranes at a cost of about £150, but that they had not entertained the offer, as they expected that both cranes would be at work shortly with every requisite appliance provided, although permission had been given the firm to make some tests as to the efficiency of the cranes, on the understanding that they paid for the current supplied. The Sheriff said he thought it would be

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understood that they were not yet taking over the electric crane, and would not do so until they were satisfied that it was competent to do the work which was expected of it according to the conditions and requirements of the contract. It did, he understood, lift about one-third of the weight it was supposed to lift and worked with that weight fairly well; but he hoped the Committee would not see fit to make themselves responsible for the payment for this crane until it was rendered capable of doing what it was expected to do. Alderman Bone, the Chairman of the Works Committee, replied that the cranes had not yet been tested, but would be in due course; and he felt sure that they would be found capable of doing the work they were supposed to do. The Committee's report was then adopted.

WAKEFIELD.—Mr. Robert Hammond has been engaged as Consulting engineer by the Corporation to prepare plans and advise the Town Clerk as to the Provisional Order which it has been resolved to apply for.

WANDSWORTH.—Mr. Sidney Morse having applied to the District Board of Works for an extension of time for complying with Section 7 of the Provisional Order granted to the County of London Electric Lighting Company, the Board have agreed to an extension of six months.

WEST CALDER.—The premises of the local Co-operative Society have been lighted by electricity for the past four years, and the plant has now been enlarged so as to form a central station for the distribution of the light throughout the district. The current was switched on on Friday last to the different circuits throughout the village.

WESTON-SUPER-MARE.—The Brush Electrical Engineering Company have supplied the Town Commissioners with an estimate of the cost of supplying the district with the electric light, but the Commissioners have decided to refer the whole question of electric lighting to a sub-committee.

WREXHAM.—On Wednesday last week a special meeting of the Town Council was held for the purpose of considering in committee a letter from Messrs. Lewis and Son, solicitors, stating that the Wrexham and District Electric Supply Company (Limited) were prepared, in accordance with the offer made by the Chairman of the Company to the Lighting Committee on April 25th, to sell to the Corporation the Provisional Order of the Company for the sum of £500. Considerable discussion took place, and it was generally held to be unwise to expend £500 on a Provisional Order which had only a year to run. The Town Clerk said that the Corporation would be able to obtain an Order for about £250, and it was eventually resolved to offer the Company this sum for their Order.

YEADON.—At a meeting of the Local Board last week a letter was read from M. Robert Hammond giving the terms on which he would prepare a scheme for the lighting of the district. The Board decided to have a further interview with Messrs. Andrews and Preece, and then to call a public meeting for the purpose of asking the ratepayers' sanction to the Board undertaking the supply of electricity for both public and private lighting.

COMPANIES' MEETINGS AND REPORTS.

Halifax and Bermudas Cable Company (Limited).

As briefly reported in last week's issue, the fourth annual general meeting of this Company was held at the offices, 33, Old Broad-street, London, E.C., on Wednesday, September 20th, when the Directors' Report (as follows) and Statements of Accounts were unanimously adopted:—

The Directors beg to submit to the Shareholders duly audited Statements of Accounts for the year ending June 30, 1893. The result of the working is a profit of £1,717. 8s. 5d., as compared with £1,261. 14s. 2d. for 1891-92. To this has to be added the balance of £1,681. 19s. 7d. brought forward from last year, making the sum to the credit of revenue £3,399. 8s. 0d. The net cable receipts in the past year were £4,856. 14s. 8d., as compared with £3,915. 13s. 3d. in the preceding year. This increase is chiefly due to a greater number of vessels calling at Bermuda for orders and to refit. The growth of this business is very advantageous to Bermuda, and it is the direct result of the establishment of cable communication. Other sources of traffic have been maintained.

The Company's cable has throughout the year worked with complete efficiency, and its electrical condition is excellent.

The Directors have during the year continued to give their attention to the one or two outstanding matters of an unsatisfactory character, due to the early experience of the Company. The loan of £9,000 had of the Gresham Life Office at 6 per cent. has, since June 30th, been still further reduced to £6,800, and the rate of interest to 5 per cent. Further, the £10,153. 16s. 10d. which appeared in the last balance-sheet as debit against capital account has been reduced to £6,754. 8s. 10d. by the application of the £3,399. 8s. to credit of revenue account.

The fund for the redemption of the debentures is now £7,995 6s. 2d., as compared with £5,175. 16s. 9d. last year.

Under the Articles of Association Mr. T. G. H. Glynn and Mr. Thomas Skinner retire on this occasion, and offer themselves for re-election. The Auditors, Messrs. Gribbon, Ingram, and Holroyd, also retire, and offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1893, pages 320-348, *&c., &c.*]

FARADAY ELECTRICAL ENGINEERING COMPANY (LIMITED).—This Company has been registered in Edinburgh with a capital of £1,600, divided into 4,600 shares of £1 each, to acquire and carry on in all its branches the business of electrical engineering as lately carried on by William M'Whirter at the "Faraday" Electrical Engineering Works, Campbell-street, Govan. The first subscribers (with one share each) are:—James Johnstone, Patrick R. Macdonald, John Macdonald, Peter Galbraith, A. H. Johnstone, Alfred Johnstone, and J. Lumsden Oatts. The first Directors are:—Peter Galbraith, James Johnstone, and John Macdonald, all of Glasgow.

JOHN FORSTER AND CO. (LIMITED).—This Company has been registered, with a capital of £5,000, in £1 shares, to carry on business as mechanical engineers, machine and engineering tool makers, boiler makers, iron and brass founders, metal workers, &c.

GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).—The annual return of this Company, made up to August 10th, has been filed. The nominal capital is £500,000, divided into 250,000 Preference and 250,000 Ordinary shares of £10 each. 180,042 Preference and 180,227 Ordinary shares have been taken up, the full amount called, and £3,602,690 paid in respect thereof.

LAING, WHARTON, AND DOWN CONSTRUCTION SYNDICATE (LIMITED). The annual return of this Company, made up to August 11th, has been filed. Out of a nominal capital of £100,000, in £10 shares, 4,516 have been taken up, and 1,130 of these have been issued as fully paid. Upon 2,260 the full amount has been called, on 329 a call of £5 per share has been made, and on £397 £2. 10s. per share has been called, resulting in a total payment of £29,237. 10s. During the past financial year 2:0 of the shares issued as fully paid have been returned and the certificates cancelled.

MIDLAND HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED).—The annual return of this Company for 1893 shows that only the seven Subscribers' shares and the 100 Founders' shares issued as fully paid to the parent Company have been taken up. No payments have been made.

ORIENTAL TELEPHONE AND ELECTRIC COMPANY (LIMITED)—The annual return of this Company, made up to September 6th, has been filed. The nominal capital is £300,000, divided into 225,000 Ordinary and 75,000 vendors, and 223,746 of the former, and all of the latter have been taken up. The Vendors' and 3,746 Ordinary shares have been allotted as fully paid. Upon the remaining 220,000 Ordinary shares a call of 11s. per share has been made, resulting in a payment of £121,000.

WATERHOUSE ELECTRICAL MANUFACTURING COMPANY (LIMITED). The statutory return of this Company, made up to May 24th, has recently been filed. The nominal capital is £20,000, divided into 1,000 Vendors' and 1,000 Ordinary shares of £10 each. All the former and 272 of the latter have been subscribed for and allotted, the former being issued as fully paid to Messrs. Addison G. Waterhouse, Frank G. Waterhouse, James N. Gamble, Francis T. Chambers, and Reginald Bolton. Upon the Ordinary shares a call of £6. 13s. 4d. per share has been made, resulting in the payment of £2,563. 6s. 8d. (which includes a sum of £2,250 paid in respect of 225 shares), leaving £156. 13s. 4d. in arrears.

CITY NOTES, &c.

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).—At a meeting of the Board of Directors of this Company on Friday, it was resolved to declare an interim dividend for the quarter ending September 30, 1893, of 12s. 6d. per cent. on the Ordinary stock and 25s. per cent. on the Preferred stock, less income-tax, payable on November 1st to the stockholders registered on the books of the Company on September 30, 1893.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended September 24th were £773, as against £768 for the corresponding period of last year, being an increase of £5. The total receipts for the half-year amount to £9,653, against £9,208 in the corresponding period of 1892, being an increase of £445.

EDISON ELECTRIC ILLUMINATING COMPANY OF NEW YORK.—The net earnings of this Company in the first half of this year amounted to $282,302, as compared with $225,566 in the corresponding period of 1892, and $152,301 in the corresponding period of 1891. The number of incandescent lamps in operation at the close of June, 1893, was 75,524, as compared with 56,704 at the close of June, 1892, and 50,615 at the close of June, 1891. The number of arc lamps in operation at the close of June, 1893, was 2,008, as compared with 1,153 at the close of June, 1892, and 313 at the close of June, 1891.

EVERED AND CO. (LIMITED).—The Directors have declared an interim dividend at the rate of 7½ per cent. per annum for the half-year ending June 30th last.

SOCIETE GENERALE DES TELEPHONES.—It is announced that the scheme for the reconstruction of this Company has now been completed, and will shortly be laid before the shareholders for their approval.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee have appointed to-day (Friday) a special settling day in the further issue of £50,000 Five per Cent. Debentures, Nos. 5,001 to 10,000, of the Metro-

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politan Electric Supply Company (Limited); and have ordered these securities and the further issue of 15,000 Preference shares, Nos. 75,001 to 90,000, and 12,022 Ordinary shares, Nos. 77,979 to 90,0 0, of the Brush Electrical Engineering Company (Limited), to be quoted in the Official List.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended September 22, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,223.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Sept. 20.		Price Wednesday, Sept. 27.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 27.	
								£ s. d.		Highest	Lowest.
			TELEGRAPHS								
£1,134,640	Stock	12/6	Anglo-American	50	51	50	51	5 7 10	Jan. Apr., July, Oct.	50	..
£2,932,680	Stock	25/0	Do. Preferred	92	93	92	93	5 18 3	" "	93	92½
£2,932,680	Stock	5/0	Do. Deferred	9½	10	9½	9⅝	..	.. ..	9⅝	9⅛
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	99	102	99	102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	11½	12	11½	12	5 8 4	Mar., June, Oct., Dec.	11⅝	11⅜
£36,400	£100	5%	Do. 5 per Cent. Bonds	99	103	99	103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107	111	107	111	4 10 1	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	135	140	136	140	5 0 0	April and October..	..	..
16,000	10	8/0	Cuba Submarine	11	12	11	12	6 13 4	February and August	11	..
6,000	10	10%	Do. Preference 10 per Cent.	18	19	18	19	5 5 3	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2⅛	3⅛	2⅛	3⅛	4 11 5	April and October...	..	..
6,000	5	10%	Do. Preference 10 per Cent.	8⅛	9⅛	8⅛	9⅛	5 5 3	" "	..	..
60,710	20	3/6	Direct United States	11⅜	11⅝	11⅜	11⅝	5 18 2	Jan., Apr., July, Oct.	11⅞	11⅜
400,000	10	5/6	Eastern	15	15½	15	15½	4 5 3	" "	15½	15
70,000	10	6%	Do. 6 per Cent. Preference	16	16½	16	16½	3 12 9	" "	16⅜	16⅛
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	111	114	112	115	3 9 7	May and November	114	112½
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15½	15⅝	15½	15⅝	4 10 4	Jan., Apr., July, Oct.	15⅞	15⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	110	113	110	113	3 10 10	February & August	111½	..
£70 6 10	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	102	105	102	105	4 15 3	January and July ..	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb.,1900	101	104	101	104	4 16 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101	104	101	104	3 16 11	February & August	102⅜	..
£200,000	£25	..	Do. 4% Mauritius Sub. Debs.	103¾	106¾	103¾	106¾	..	May and November	104⅛	..
180,227	10	4/0	Globe Telegraph and Trust	9⅜	9⅝	9⅜	9⅝	4 13 8	Jan., Apr., July, Oct.	9⅝	9⅛
180,042	10	6%	Do. 6 per Cent. Preference	15½	15⅝	15½	15⅝	3 18 1	" "	15⅝	15½
150,000	10	5/0	Great Northern	20	20½	20	20½	4 3 0	Jan., April, and July	20⅛	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	103	106	103	106	4 14 4	March & September	103½	..
17,000	25	37/6	Indo-European	39	42	39	42	5 19 1	May and November	..	..
37,548	10	4/0	London Platino-Brazilian	4	6	4	6	3 6 8	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh.4% Guar. Debs. "Red' 1942	100	103	101	104	3 16 11	..	..	..
11,802	8	4/0	Reuter's	4½	5½	4½	5½	..	April and October...	..	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6 per Cent.	115	120	115	120	5 0 0	" "	118	117½
15,609	10	5/0	West African Telegraph	5½	6½	5½	6½	7 13 10	January and July ..	..	..
£260,900	100	5%	Do. 5 per Cent. Debentures	97	100	99	100	5 0 0	March & September	99½	99⅛
30,000	10	2/0	West Coast of America	2	3	2	3	..	January and July ..	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	97	101	97	101	7 18 5	June and December	..	..
88,321	10	6d.	West India and Panama	1⅛	1⅜	1⅛	1⅜	..	..	1 5/16	1⅛
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½	10⅝	10	10½	5 14 3	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9	10	9	10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	106	109	106	109	4 11 9	June and December	..	..
54,242	15	4/6	Western and Brazilian	6½	7	6½	7	5 7 6	May and November	..	..
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5⅝	6⅛	5⅝	6⅛	..	..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1⅛	1⅜	1	1⅛	..	..	..	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 13 2	February & August	..	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	115	120	115	120	5 16 8	May and November	..	..
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	101	104	101	104	5 15 5	March & September	104½	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	2	3	2	3	..	..	..	..
22,500	10,0	3½d.	Consolidated Telephone Const. & Maintenance	1 1/16	1 3/16	1 1/16	1 3/16	..	May and November	..	..
250,000	£1	4/6d.	Oriental (11s. paid)	1 1/16	1 1/16	1 1/16	1 1/16	7 18 2	Yearly	..	..
458,867	5	2/6	National	4½	4⅝	4⅝	4¾	5 2 7	June and December	4 13/16	4 3/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14	15	14	15	4 0 0	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	13½	14½	13½	14½	4 2 9	" "	14½	..
90,950	5	2/0	Do. 5% Non-Cumulative 3rd Pref.	5½	5⅝	5½	5⅝	4 13 0	.. ..	5 5/8	5½
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	112	114	112	114	3 18 11	January and July ..	113½	113
58,000	5	1/0	United River Plate	2	2½	2	2⅝	..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	11½	11¾	11½	11¾	–	–	11⅝	..
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12⅛	13	12⅛	13	..	–	12⅝	12 3/16
19,900	£5	..	Electricity Supply Co. for Spain	..	..	..	..	..	–	–	–
£150,000	£5	..	Electricity Supply Company Ordinary	..	5	..	5½	..	–	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	–	..	..
8,322	£5	..	House to House Electric	..	1½	..	2½	..	–	–	–
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..	5⅛	..	5⅝	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	6	..	6½	..	January and July ..	–	–
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4⅛	4½	4⅛	4½	..	..	–	–
15,000	£5	5/0 '92	Do. (fully paid)	6	6½	6	6½	..	..	–	–
111,000	5	..	London Electric Supply	¾	1	¾	1	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6¾	7¼	6¾	7¼	2 15 2	..	7⅛	7
50,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	104	107	104	107	4 13 6	June and December	..	..
6,452	£10	..	Notting Hill Electric	5	6	5	6	–	–	..	..
19,980	£5	9½%	St. James' and Pall Mall	6½	6⅞	6½	6⅞	..	–	6⅞	6⅝
20,000	£5	7%	Do. 7 per Cent. Preference	8	8½	7⅞	8¼	4 4 10	–	8⅜	8
59,900	5	1/6	Westminster Electric Supply (fully paid)	4⅜	5½	5	5½	3 3 8	–	5½	5⅛
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	2/1	Brush Electrical Engineering	2⅜	3⅛	2⅞	3⅛	..	–	3	..
75,000	2	6%	Do. 6 per Cent. Preference	2⅛	2⅜	2⅛	2⅜	5 1 1	–	2⅛	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	106	108	107	109	4 2 7	March & September	..	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	3½	4½	3½	4½	..	January and July –	..	..
12,139	5	..	Edison and Swan United	–	–	–	–	–	–	–	–
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..	..	1¾	2¼	..	–	..	..
49,900	10	12/0	Electric Construction	1½	1⅝	1½	2¼	..	–	1 1/16	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜	½	⅜	½	–	–	–	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1	2	1	2	..	–	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½	22½	21½	22½	5 11 1	February & August	22⅝	22⅛
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	101	103	4 7 5	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	1	2	1	2	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	..	..	..	..	..	December and June	–	–
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/0	4/0	3/0	4/0	..	–	–	..
78,949	5	1/9	Swan United (£3. 10s. paid)	2	2½	2	2⅛	13 19 8	May and November	2⅜	2⅛
37,350	12	12/0	Telegraph Construction and Maintenance	32	34	32	34	5 5 10	March and July.....	33½	33
£150,000	100	5%	Do. 5 per Cent. Bonds, red.1894	101	104	101	104	4 16 2	January and July –	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	..	..	..	..	–	–	–	–
41,098	£5	..	Do. Preference (fully paid)	..	..	..	..	–	–	–	–
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	3%	City and South London Railway	35	37	34	36	2 1 8	May and November	..	..
37,500	£10	..	Liverpool Overhead Railway	5½	5½	5½	5½	–	–	–	–

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 803.—Vol. XXXI. FRIDAY, OCTOBER 6, 1893. PRICE FOURPENCE. *Annual Subscription (U.K.), 19/6*

NOTES.

By the death of Sir Arthur Blackwood the Post Office suffers a bereavement far more serious than would be occasioned by the mere loss of a valuable and popular chief. During the twenty years that he held high office Sir Arthur was foremost in every movement for the advancement of the service and the well-being of its employés. Dominated by a strong religious personality, he has exerted, notably on the rank and file, an influence which will be more enduring probably than his fame as an administrator. Popular in every branch of the service, he was best known, perhaps, in the telegraph section; and the good work done among the messenger boys, under his never-tiring guidance, has achieved wonders in raising the moral tone and physical welfare of the rising generation of postal and telegraph servants, whose ranks are recruited from that body.

The letter from Dr. Lodge in our correspondence columns this week, referring to the Sectional work of the British Association, is very much to the point. The value of this Association to Science arises, we think, from three causes. In the first place, a number of most valuable reports have been presented from time to time, which have been carefully prepared by the greatest authorities on the subjects of which they treat. They at once take the standing of classical work, and are frequently referred to in after years. Then, again, there is all the work which has been done in connection with the determination of the electrical standards. This work has from the first been a speciality of the British Association, and its great importance is universally felt, but is, in a sense, accidental, since it is generally supposed that one of the main objects of the Association is to popularise science. The holiday nature of the gathering attracts the attention of the outside public, and, perhaps, if the holiday spirit were more apparent in the meetings than is at present the case the success of the Association would be greater than it is.

We agree with Dr. Lodge that serious Papers are not much wanted at these gatherings, and if this were more generally recognised, such complaints as that of Mr. Walker in our last issue would not be made. The outside public go to hear and see celebrated scientific men. This is also partly the object of many of the members themselves; but to them the chief value of the meetings lies in the reception of new ideas, and these are more likely to be imparted in an informal discussion in which many take part, than in the reading of a number of Papers, to the exclusion of discussion. We have ourselves little doubt as to the existence of a feeling of dissatisfaction among many of those who attend the meetings of the British Association, although no one, as far as we know, has imparted any blame to those who are responsible for the manner in which these meetings are conducted.

The common complaint that the Sectional committees mainly consist of cliques appears to be due to the erroneous idea that the reading of Papers is the primary work of the Sections. This idea is encouraged by the reticence of the committees as to the titles of the Papers which have been received or definitely promised, and the fact that all outsiders are kept in ignorance of the programme for any day until nine o'clock on the morning of that day, while members of the committee are acquainted with it about sixteen hours previously. They can easily settle their plans for the morrow, while outsiders, fearing lest they may miss something important, can make no plans until they see a copy of the programme at the reception room or in some enterprising local newspaper. The committee becomes a clique rather perforce than by intention, and if our estimate of the general opinion of outsiders is correct, there is no other cause for dissatisfaction worth mentioning. "Friendly and mutually helpful impromptu discussion" has always been the most attractive feature, especially of Section A, but to rely on impromptu discussions would be unwise in any association with less zeal than the Society of Friends. Dr. Lodge, however, appeals not to us but to our readers, and we readily invite the discussion which he suggests.

The effect of the presence in an electrolyte of more than the conventional number of conductors serving as electrodes, seems to be in process of becoming a favourite object of study among physicists, for following on the investigations of Dr. Oettel to which we have recently devoted some space, comes notice of a Paper by Mr. John Daniel, entitled "Polarisation, Using a Thin Metal Partition in a Voltameter," dealing with a different aspect of the same or a similar phenomenon. The behaviour of a metallic diaphragm interposed between anode and cathode so that communication from one to the other must take place through the partition, varies with the nature

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of the partition, with that of the electrolyte and with the current density. In general, gas is evolved at the surface of the partition when its thickness exceeds a certain limit, while no sign of activity occurs when the limit is not reached. A natural corollary of this is that very thin diaphragms escape the oxidising effect of the products of electrolysis, while those that are thicker are attacked even to destruction. The observation suggests many interesting speculations, but from these we refrain until a few preliminaries are settled. In the first place, it is necessary to be certain that the partition constitutes an absolute mechanical means of separation. Then, moreover, proof of the absence of molar spaces in the partition itself is requisite. All who have held a piece of tin-foil up to the light will know what a riddle an apparently continuous metal sheet may be, and will scarcely undertake the solution of a problem containing an unknown number of unknowns. We await the publication of the complete Paper with much interest.

A Paper read by Dr. Bodländer at the recent congress of the German Society which corresponds pretty closely with the British Association, deals with the vexed question of the subsidence of finely divided matter in suspension in liquids, and endeavours to explain it by appeal to the magic term electrolysis, which is fast ousting polarisation from the position of consoler to the perplexed electrician who clings to elegant periphrasis when elucidation is not forthcoming. The author of the Paper finds that the clarification of a turbid liquid is promoted by the addition of substances which are electrolytes, such as acids, bases and salts, while bodies of the class of alcohol and sugar have no such influence. It may be remarked in passing that this is scarcely consonant with ordinary analytical experience in dealing with argillaceous materials, which remain obstinately in suspension in alkaline solutions although promptly precipitated when an acid is present. This may, however, depend on the fact also observed by Dr. Bodländer, that the clarifying effect is not perceptible below a certain limit of dilution. The vigour of the action of the alien substance inducing precipitation, increases with its conductivity, leading to the hypothesis that the effect of the electrical charge possessed by each ion of a dissociated electrolyte, may be analogous to that of the discharge from the poles of an influence machine in a dusty atmosphere which causes the agglomeration of the finely divided particles. Whatever the *vera causa*, it is certain that many substances when suspended in water free from electrolytes pass into a state of subdivision so fine as to be indistinguishable from the solution of a colloid and precipitable by the addition of an electrolyte. A practical deduction is that calcium chloride and magnesium chloride, both cheap salts, can be advantageously used for the clarification of turbid waste waters from manufacturing processes. The formation of a delta, on contact of a turbid river water with the saline sea, might to some extent be ascribed to the same action.

Had proper care been exercised in arranging the details of the tug-of-war which recently took place at Chicago between a steam locomotive and the 30-ton electric locomotive, described in *The Electrician* of July 28th, page 344, there is no doubt that much greater importance might have been attached to the results. The nominally 30-ton locomotive, which, however, weighed but 27 tons, was pitted against a small steam locomotive having a weight of 28½ tons on the driving wheels, or 1½ tons in excess of its opponent. Thus much was in favour of the steam locomotive, though with other conditions equal it could not have told much in favour of the heavier engine. On the other hand, the electric locomotive had a very decided advantage from the fact that its most powerful effort occurs under statical conditions, and is very much more in excess of its running effort than is the statical effort of a steam locomotive as compared with its running effort; assuming, of course, that there is a normal pressure on the mains of the one, and a normal pressure in the boiler of the other. As far, then, as the mere useless experiment is concerned of statically pitting a steam locomotive against an electric locomotive of equal weight, we have every reason for predicting the "triumph" of the latter.

But there are two obvious criticisms upon the tests made at Chicago. In the first place, the tests are absolutely unreliable and useless, because, if we are correctly informed, the level of the drawbar was not parallel with the rails, but was tilted in a manner to cause the trailing wheels of the electric locomotive to lose their grip of the rails, thus throwing the burden upon one motor alone. In the second place, such a trial as this, even if carried out under conditions which would make the comparison a fair one, can give but little indication of the true relative merits of the several engines. Even granted that, statically, the electric locomotive is the superior, it will by no means necessarily follow that it will draw a greater load of coaches at any really useful speed than its steam rival. In fact, it might be safely predicted that of two locomotives of ordinary design, the one steam and the other electrical, having equal weights and giving an equal statical effort on the drawbar, the former would be found capable of drawing the greater load at any given speed. It is therefore not on these, but on totally different grounds of comparison that the electric locomotive can either claim or be expected to acquire any useful ascendency over the steam locomotive.

The Paper by Prof. Carhart on "Arc Lamps," which was read before the Chicago Congress, is printed in our present issue, because the curves which accompany it contribute some information, although the observations, as in most photometric tests of arc lamps, are very irregular. We must, however, call attention to the fact that these results cannot be considered as representative of good arc lamps. We know nothing of the quality of the carbons of the Standard Carbon Company, of Cleveland; but we cannot attribute the very poor result to bad carbons. The most obvious reason for so low a candle-power seems to be the use of carbons of the same diameter for both positive and negative. This common practice has no excuse when cored carbons are used for positives and plain carbons

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for negatives. In the old days of 11mm. carbons for top and bottom nobody cared about watts per candle-power or for sputtering and fireworks.

Since the exhaustive and trustworthy tests of glow lamps at the Franklin Institute, in conjunction with the Philadelphia Exhibition some years ago, no systematic and complete set of lamp tests has anywhere been made. The Philadelphia tests were, for some time after their publication, a mass of reliable information on the life, efficiency and candle-power of glow lamps. But time has worked such changes, both in the mode of manufacture of the lamps themselves and in the practical conditions under which they are worked, that it is necessary to look around for a mass of fresh data which shall take the place of the older information. We look around in vain. With the exception of the disconnected and incomplete researches—valuable as far as they go, but telling us really nothing final—of some experimenters in this country and in Germany, there is no material at our disposal. In another column we print an abstract of the arrangements which have been made for some glow-lamp tests at Chicago. Our readers may judge for themselves whether much commercial or practical value can be attached to lamp tests which, arranged to commence on September 8th, will be continued only (Sundays not included) till the end of October. The maximum time under which a lamp can be tested will be about 1,130 hours; and, these being without any intermission other than the Sunday hours, it is evident the conditions imposed on the lamps cannot fairly be considered to resemble those of actual practice. Life tests of this sort, and with the arrangements for maintaining a perfectly steady pressure which have been adopted, can have nothing but a fanciful and fictitious significance, and will be no guide to either the engineer or the consumer as to the relative merits of the lamps when at work on ordinary lighting mains. It is quite time the solid work of the Franklin Institute tests was repeated upon modern lamps.

Erratum.—In the article on "New Lamps for Old" in our last week's issue the expression "lamp hours" was inadvertently used in one or two cases for "candle hours." In all cases "candle hours" were intended, and the expression "lamp hours" should not have been employed anywere in the article.

Electric Traction for the St. Clair Tunnel.—The St. Clair Tunnel Company are still considering the advisability of adopting electric traction on the trains running through the tunnel, and have now got as far as to obtain estimates from the Canadian General Electric Company for an electric equipment.

Very Curious.—A daily newspaper across the Atlantic thinks it is "a curious anomaly that at the very time that the application of electricity to all the purposes of civilisation has shown such an extraordinary development the demand for steam-engines has increased in almost the same proportion." It is equally curious that the demand for flour has increased in proportion to the demand for bread.

Electric Motors in Factories.—A twelvemonth ago we described the 500 H.P. dynamo at Herstal which generates current for driving the Small Arms Factory, the whole of the machinery being thus driven. Early this year another large dynamo was set to work, coupled direct not to a Corliss engine as in the former plant, but to a 300 H.P. compound Willans central valve condensing engine, running at 350 revolutions per minute.

Shovelling the "Elastic Solid."—Prof. Lodge, says the *Journal of Gas Lighting*, talked about the ether at Nottingham, and he was listened to respectfully. But the question at issue was left exactly where it stood before he opened his mouth. We do not wish to write disrespectfully of the undulatory forces, remarks our contemporary, but it would be an immense relief to the mind if someone could only succeed in getting at the ether with a shovel!

Memorial Willans Fund.—We are asked to mention that the subscription lists for this fund will be closed on November 1st, so that any engineers or others who intend to send in subscriptions, and have not done so, should do so at once. Mr. Alexander Siemens, 12, Queen Anne's-gate, Westminster, is the treasurer of the committee. It may be remembered that the proposal is to establish a fund in connection with the Institution of Mechanical and Electrical Engineers, from the interest of which a premium might be awarded for Papers relating to the subjects which the late Mr. Willans made so peculiarly his own.

Japanese Coal.—Japanese coal (the Vice-Consul at Nagasaki, Japan, reports) is becoming one of the most important articles of the foreign trade of that country. It is, he says, competing with advantage in the way of better market, more rapid production, and less waste with the coal supplied from England and Australia to the markets of China and Singapore. This applies specially to the requirements of navigation, railways, and steam. The coal mines of Japan have reached the total yield of 3,000,000 tons per annum. Japanese coal is stated to be in favour at foreign markets, and its consumption in its own country is also on the increase. An analysis of the Japanese coal gives the following result:—Carbon, 79·26; hydrogen, 5·86; oxygen, 8·76; sulphur, 0·11; ashes, 4·56; water, 1·50. It will be seen that this fuel is more bituminous, and has a higher evaporative power than the average English steam coal.

Mathematical Signs.—In France and Germany one-fourth ($\frac{1}{4}$) reduced to a decimal is written as 0,25; in England it is written 0·25 (always with the period at the top of the line), and in the United States in this way, 0.25. Sir Isaac Newton is given the credit of originating the English method of using the decimal point, his reason being that by placing it at the top of the line it could be distinguished at a glance from the "full stop" punctuation mark. All English mathematicians use the mark in the way proposed by Newton, and the period as a sign of multiplication. It is satisfactory to note that the French show signs of conversion to the English method of marking the decimal place. For instance, in a recently published electrical pocket book the author, in a table of squares, cubes, and reciprocals, calls attention to the fact that "la virgule est remplacée par le point relevé," but in all other tables the, to us, confusing comma has been left in. In subsequent editions it is to be hoped that this reform will no longer make a full stop at the table of squares.

The Measurement of Self-Induction.—In a recent number of *La Lumière Electrique*, M. Blondel discusses the various methods of measuring the self-induction of an electric circuit, the magnetic circuit through which possesses variable permeability. M. Blondel rightly points out that on strictly logical grounds the expression "coefficient of self-induction" is not applicable to this case of inductance, as the inductive effects are functions of the degree of magnetic induction. But he adds that in certain investigations it is convenient to introduce into the expression for the electromotive force due to self-induction, one or the other of two analogues of the usual coefficient. The first of these is the differential coefficient of the magnetic flux with respect to change of current; the second is the ratio of the total magnetic flux to the total current producing it. The former, of course, gives the instantaneous value of the self-induction; the latter represents its integral between limits of zero and the magnetic induction at the instant. In the latter part of his Paper, M. Blondel discusses the application of these two functions and the modes of measuring them.

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St. Petersburg.—The one hundredth anniversary of Faraday's birthday was celebrated in a not inappropriate manner at St. Petersburg, on September 10, 1891, by laying the foundation stone of the electric light station at the Imperial Medical Academy. Exactly one year later the first electric light supplied by this station was run, probably an intentional "coincidence." Whether anything extraordinary happened at this station on September 10th of this present year we cannot say, but during the last twelve months considerable progress has been made. The whole area, says *Engineering*, is about one square mile, and the system chosen was high pressure, alternating current, with transformers. The station is situated on the Neva, to facilitate the supply of water and coal. The following losses in the cables were allowed for:—In the primary and secondary cables 2 per cent., in the dynamos and transformers 8 per cent., giving a total drop of 12 per cent. The engines are vertical triple-expansion engines, each of about 350 H.P. indicated. Two of these are now at work, and a third is being erected. These engines are direct-coupled to large Ganz alternators, capable of an output of 200 kilowatts at 2,000 volts. The leads outside the station are of bare silicium bronze wire, protected over steel crossings by steel bearer wires. Oil insulators are used. According to some recent tests, the consumption of coal and water per indicated horse-power hour is 1·54lb. and 13·4lb. respectively, but the more useful tests of the consumption per electrical horse-power hour do not appear to be forthcoming.

Energy and Entropy.—The decomposition of any form of energy into two factors, one of which is of a constant magnitude, says *Nature*, introduces certain simplifications into the theorems of thermodynamics and chemical physics which appear to merit some attention. Herr W. Meyerhoffer, in the *Comptes Rendus*, points out that the constant factor in the case of heat is not the entropy, as maintained by M. Le Chatelier, but the absolute specific heat, which has the dimensions of an energy divided by degrees of temperature. Entropy, on the other hand, is an energy divided by a number representing the number of degrees possessed by the heat at the time of its passage, and which Herr Meyerhoffer proposes to call the number of the isothermal. The confusion between entropy and absolute specific heat arises from the fact that the dimensions of temperature are at present unknown. Herr Meyerhoffer proposes to call the two factors of energy capacity and potential respectively. Then every transfer of heat will involve a change of two potentials, and the criterion of a reversible process will be the inequality of the two potentials. All the cycles invented since Carnot have always had the same function of transforming the variation of one potential into that of another of different nature. By means of this division of energy, most of the known stœchiometric laws can be reduced to one, thus:—The smallest particles of matter have, in a comparable state, the same capacity of energy. By going through the various forms of energy, Regnault's law concerning the specific heats of gases, and the laws of Dulong and Petit, Faraday, Eötvös, and Dalton may be severally obtained.

The Want of Light in Public Conveyances.—The great companies that carry the travelling public, says the *Lancet*, whether in omnibuses or in railway carriages, display a very inadequate sense of their duty in the matter of providing light. Last year it seemed as though the General Omnibus Company was about to set an excellent example. It introduced the electric light into the centre of the omnibus, instead of the oil lamp at the door that only seemed to make the gloom of the inside more depressing. At first it seemed as if the passengers would be able to beguile the time by reading newspapers or books; but the light has become small by degrees, and is altogether inadequate for any such pleasant purpose. On the railway lines, with but few exceptions, the same semi-darkness reigns. The Midland Railway, we believe, has a few trains on the main line fitted with the electric light; but we lately travelled about twenty miles in practical darkness. The Great Northern Railway has attempted to do its duty in this matter in some trains, but has receded rather than advanced in the attempt. The South-Eastern Railway has tried the slot system in some of its trains, and for one penny the passenger could get half-an-hour's light to read by, but on the whole the companies favour darkness rather than light. We protest strongly against the persistence in this state of things as one altogether out of date. Men and women spend too much of their time now in travelling for this to be tolerated. Our protest is in the interest of the public and of the eyes of our patients, but the interest of the railways and the omnibus companies would also surely be served by the reform, and we strongly advise the public to patronise the company that is most generous in the matter of providing efficient light.

Smokeless Combustion.—Some trials at Berlin for securing complete combustion with the absence of smoke have, it is stated, induced the North German Lloyd and the Hamburg American Packet Company to adopt the system, which is thus described:—Coal, reduced to powder—not necessarily very fine, however—in centrifugal disintegrators, is introduced into a pear-shaped combustion-chamber lined with firebrick, and fitted with an induction apparatus like those used in petroleum-fired furnaces, the coal-dust being drawn along by a jet of steam or compressed air. The combustion chamber, which takes the place of a furnace, is provided with two apertures, one in the centre line of the boiler—in case of such an application, for instance—occupying the position of the usual fire-hole door, while the other, on the opposite side of the combustion chamber, serves for introducing the coal-dust through a pipe, so placed that the dust is evenly dispersed over the whole extent of the chamber. After the first ignition of the dust, which may be affected by any source of heat, the combustion is said to continue very intensely and regularly under the action of the air current, which is regulated in accordance with the quantity of dust necessary to produce the degree of heat for the required amount of steam. The air or steam and coal-dust are intimately mingled in the zone of combustion, while the speed of the current, which has served as a vehicle for the dust, is very much reduced. Each particle of fuel held in suspension is, by this method, brought into such intimate contact with the oxygen necessary for its combustion, that this combustion is so complete as to allow scarcely any smoke to be perceptible. In inter-mural electric light stations, where it is very desirable to minimise the smoke nuisance, some such system as this will probably prove to be valuable.

The "Philosophical Magazine."—The October number of the *Philosophical Magazine* contains several Papers of electrical interest. The number opens with a Paper by Prof. J. J. Thomson on "The Effect of Electrification and Chemical Action on a Steam-Jet, and of Water-Vapour on the Discharge of Electricity through Gases," which deals with the formation of water drops under various conditions of pressure, temperature, and electric stress, and refers the effects of chemical action on steam-jets to a condition of electric stress caused by atomic charges. The Papers by Lord Kelvin "On the Piezo-electric Property of Quartz" and "On a Piezo-electric Pile," which we published in abstract, and which were read at the British Association this year, are published *in extenso*. Mr. J. Trowbridge contributes a Paper "On the Oscillations of Lightning Discharges and of the Aurora Borealis," in which the artificial conditions of experimental sparks and discharges and the natural conditions under which lightning flashes and auroræ occur, are compared. It is puzzling that, in Papers of this sort, we never hear anything of the Aurora Australis—it is always the northern phenomenon which is discussed. An extract from this article will be found in another Note. The Note on "Endothermic Reactions Effected by Mechanical Force (First Part)," by M. Carey Lea, is interesting when considered in conjunction with the piezo-electric property of crystals, &c., described by Lord Kelvin. It deals with various endothermic chemical reactions produced by mechanical pressure, and concludes with the general deduction "that mechanical force can bring about reactions which require expenditure of energy, which energy is supplied by mechanical force precisely in the same way that light, heat and electricity supply energy in the endothermic changes which they bring about." Dr. Sophie Bryant contributes an application of determinants to an example of "Correlation of Averages," where there are four variable quantities, a subject which, though somewhat beyond the range of everyday work, is not without interest to electricians.

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ELECTROMAGNETIC THEORY.—LV.

BY OLIVER HEAVISIDE.

(Continued from page 519.)

§213. First, as regards long land lines, of say 400 miles in length (which is a long distance in this small country), leakage presented itself as an unmitigated nuisance. The worst case of all was during a continuous soaking rain all over the country. When this had gone on for a few hours the insulation resistance fell so low, by leakage over the dirty wet insulators mostly, though assisted by contacts with wet foliage, &c., that many of the important circuits were completely invalided, the received current (even with increased battery power) being too small for practical use with the instruments concerned. This was usually the case in the U.K. on any very wet day. But it was also the same in effect in the E. and I., although not so many lines were invalided, nor did they break down so quickly.

Incidentally, it may be mentioned here that the so-called "earth-currents" (meaning currents *in the line* itself), occurring during magnetic storms, such currents being a manifestation thereof, did not seem to mind the leakage much, perhaps because their E.M.F. was not like that of a battery at one end of a line, but acted continuously along the circuit, by a continuous slow change going on in the earth's magnetic force, or, rather, in the magnetic force in the air surrounding the earth. Probably the "earth-current" goes the same way in the line as in the earth (provided the line is not set at right angles to the real earth-current), whereas when a battery is used, the earth and line-currents are opposed. But it is not easy in wet weather to get a good magnetic storm, so that close observations can be made regarding the influence of leakage on earth-currents. We may dismiss them, and sum up that, as regards land-lines, leakage does not seem to have a single redeeming feature.

The effects of leakage next presented themselves to me on cable circuits with land-lines attached, and were exceedingly curious. There were two circuits of the kind, but one in particular had a varied history as regards leakage. It was a cable of about 400 or 450 miles running east and west, having a land line of 120 miles at the east end, and one of 20 miles at the west end. The apparatus used was the Wheatstone automatic, that is, an automatic transmitter and a polarised receiver, recording dots and dashes, and the working was done without condensers, by utilising the earth direct to complete the circuit.

The best results were obtained in fine dry weather with a hard frost—the harder the better. The insulation of the long (east) land line was then at its highest, and the signalling could be done up to 30 words per minute or a little more from west to east, though considerably less the other way, for a peculiar reason. But this was quite exceptional, and did not last long. The next best was in any very dry weather. But in ordinary average fair weather, not rainy or damp, the speed was much lower, say 24 or 20 words per minute. The effect of rain was always to lower the speed, perhaps down to 15 words per minute. A leakage fault on the land line or a contact with another wire had a similar effect, only worse, provided it was a bad fault, and the speed would go down to 10 words per minute or less. Now it is possible that the extra good results obtained in a hard dry frost arose partly from the reduced resistance of the east land line (the usual iron wire), but there was no doubt at all that the main cause of the wide variations of speed was leakage on the land lines, especially on the long one, of course.

Now it is to be noted here that in the former case of long land lines the leakage was prejudicial by the attenuation it caused, whereby the received currents were made too feeble to suit the apparatus. The working speed, though relatively fast, was too slow for any notable distortion of signals in transit by the condenser action so marked in cables. But in the latter case, of a cable with terminal land lines upon which similar leakage occurred, the prejudicial effect was not due to the attenuation. There was plenty of current—in fact, a superabundance—but it did not come out at the receiving end properly shaped for making dots and dashes, except at a greatly lowered speed. It should also be understood that the actual speed of working was always pushed up to the greatest possible (the press of business being such as to make 25 hours work per day all too short), and that the automatic character of the signalling made the fixation of a limiting speed, without complete failure of any marks, quite definite at any particular time. Practically, however, the working speed was pushed a good deal higher than this limit by making regular use of mutilated signals. Now it was proved by daily experience that there was a remarkable sensitiveness to damp, or leakage of any kind, the speed of working, conditioned by the reception of good marks, going up and down like the barometer, though with a far wider range than that instrument. The east land line was so manifestly the offender that it came in for a great deal of blame. Yet it was not a bad line by any means, and its leakage would have passed unnoticed, had there not been such a peculiar lowering effect on the speed connected therewith.

But how about leakage in the cable itself, seeing that the above results were so out of harmony with what they should have been, by general reasoning regarding retardation? This question was soon answered by the automatic development of a first-class leakage fault in the cable. Its effect on the speed was substantially the same as that of leakage on the land-line. It lowered the speed, and since it was always on, the effect was permanent. The ordinary fluctuations disappeared in a great measure, as of course did the fine weather high speeds. It was like continuous heavy wet. As the fault got very bad the speed went down to 10 words per minute or less, in spite of increased battery power.

On describing this prejudicial effect of leakage to the electrician of the cable ship which came to remove the fault (it was the late Mr. S. E. Phillips, of Henley's), he assured me I was quite wrong. It was impossible for a leak to act like that. So said the captain, too. It was known, said they, that a leak was an excellent thing. It had been found so on the French Atlantic not long before, and in other cases. I fully believed this, because it seemed theoretically sound, and I had heard similar statements before. But they did not assist me to an understanding of the patent fact that leakage could be highly prejudicial instead of beneficial. In corroboration of this, when the fault was removed, the speed went up again, and the normal state of things was restored.

The next stage in this history was the arrival of that wonderful instrument, Thomson's recorder, which had been recently brought out. It was the original Atlantic cable pattern, with 20 big tray cells for the electromagnets, and a batch of smaller ones for the mousemill and driving gear. This instrument simplified matters greatly, for the current could be considered as and seen to be a continuous function of the time, whereas with the polarised recorder of Wheatstone (an instrument quite unsuitable for cable work) the variations of the current could be only roughly guessed.

Now, a peculiarity of the siphon recorder was that no definite limiting speed was fixable. If one person thought 40 words per minute fast enough for good marks; another, more practised, would as easily read them at 50 or 60, and even manage to make them out at 70 words per minute, though the last was undoubtedly rather troublesome. The automatic transmitter being still used, the dashes became big humps, and the dots little ones, on the recorder slip, and at 70 words per minute, although the big humps were plain enough, the little ones were mostly wiped out, though it could be seen where they ought to have been, so that some reading was possible. The absence of a definite limiting speed under given circumstances introduced a fresh complication. Nevertheless, a careful study of the recorder slips taken at various speeds, but particularly in the neighbourhood of the critical speed for the polarised recorder, proved that the plain result of general reasoning that leakage should be beneficial in general was certainly true, and, moreover, furnished a partial explanation of the anomalous behaviour of the polarised recorder.

The siphon (Thomson) recorder, with its shifting zero, was sublimely indifferent to the vagaries of the current which were so distructive of intelligible marks in a dot and dash instrument, so that ordinary leakage passed quite unobserved as a rule. Nevertheless, it was plainly to be seen that when there was much leakage the result was to improve the distinctness of the

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marks by reducing the range of variation of the current from the zero line, and improving the dots, or small humps, relatively to the dashes, or big humps, which were reduced in size.

But, to clinch the matter, a second leakage fault appeared in the cable whilst the siphon recorder was on, and rapidly developed. Now, it was only at the west end that there was a siphon recorder; at the east end was the polarised recorder. The result was that the speed from west to east went down greatly as the fault developed, in accordance with prior knowledge. But the other way, from east to west, receiving with the siphon recorder, the working was greatly improved. The ultimate result was that when the fault got very bad no marks at all could be got at the east end, even by key-sending, owing to the great attenuation, whilst we could receive first rate on the siphon recorder at the west end. On the very last day, when communication from west to east had to be done by a roundabout course, we were able to receive a long batch of, I think, 150 messages at high speed (about 55 or 60 words per minute) by using 80 Leclanché cells at the sending end, and putting on the electromagnets all the tray batteries available, including most of the small ones, to magnify the marks. Now this might seem to be merely a testimony to the sensitiveness of the instrument. But the significant point was that although the marks were very small, in spite of magnification by increased battery power at both ends, they were exceedingly clear. They were the best ever got at the speed. We were practically working past a fault of no resistance, for the cable soon gave up the ghost. The tail end of the big batch finally degenerated to a straight line, indicative of a very dead earth.

On the removal of this fault, the received current was largely increased of course. But, simultaneously, the distortion of the marks on the siphon recorder became huge at the speed 60. It needed to be much lowered to give conveniently readable marks.

§ 214. Now the above facts gave a decisive and cumulative proof that leakage was beneficial even when concentrated at a single spot, provided the current-variations were recorded in a simple manner. But a complete explanation of the very large decrease in the speed possible when the polarised recorder was used, turned out to be rather a complicated matter in detail, although sufficiently simple in the fundamental principle. This effect, so detrimental to an efficient use of the cable, was mixed up with another one, viz., a difference in the working speed according to direction, of say 25 per cent. (with the same instruments), but variable with circumstances. This effect, again, seemed to have two causes, one depending upon the circuit, and the uncentrical position of the cable in it, independent of the kind of instruments used; whilst the other was special and peculiar to the automatic transmitter and receiver when combined with the uncentrical position of the cable. It may be readily imagined that the resultant effect on the working speed requires some study to be understood. It will be sufficient here to mention the instrumental peculiarity in its relation to the detrimental effect of leakage.

The original automatic transmitter of Wheatstone was constructed to make dots only upon the slip of a special receiver; there were two rows of dots, one set being for the dots, and the other for the dashes of the Morse code. But when the inventor wanted the E. and I Co. to take it up, they demanded dots and dashes, as usual. So the instruments had to be modified. Now I have personal reason to know that a few years later the inventor was quite at sea as to the reason of the peculiar effects observed in working his instruments on composite circuits and cables. It is therefore pretty safe to assume that previously, when the conversion was made, the manner of the conversion, from making double dots to dots and dashes, was dictated purely by considerations of mechanical convenience, and this conclusion may be made nearly certain by a comparison of the original with the modified transmitter. But Mr. Stroh knows all about it. At any rate, the peculiar way of making the dash and the long space was the cause of all our trouble with leakage, which cost the Company an immense sum of money, viz., what they might have gained otherwise, for they were blocked with work, and might have had much more.

To make a dot, a short positive current was sent, immediately followed by a similar short negative current. To make a dash, after sending the first short positive current, there was an interval of no current lasting twice as long as the first current, followed by a short negative current which terminated the dash. Similarly, to make a long space, a short negative current came first, then an interval of no current, and finally a short positive current. Now in these intervals of no current, the sending end of the line was insulated. When sending current, on the other hand, the line was to earth, through the battery. Two distinct electrical arrangements were therefore operative in turn, viz., a cable with both ends earthed, and a cable with only one end (the receiving end) to earth. If the former system always prevailed, the manner of transmission of electrical changes would follow one law. If the latter system prevailed, it would follow another law, and would give much greater retardation. In real fact, the two ways were in alternate action irregularly. This has to be considered carefully in examining the influence of the uncentrical position of a cable in a composite circuit, and also of leakage.

Now the practical effect worked out thus. There was a real positive and material advantage in making the dash and long space of the Morse code by a short initial current instead of a long one, as in ordinary working with reversing keys. I estimated the gain as amounting to from 100 to 125 per cent. under favourable circumstances. This implies that the limiting speed is really worked up to. But it was vitally necessary to secure this advantage, that the insulation should be very good. A peculiar balance had to be preserved between the positive and the negative currents. The currents were of equal duration and of alternate signs, but necessarily not equidistant in time. Now, with exceedingly good insulation, the short current sent at the beginning of a dash was sufficiently prolonged in reception as to not merely make a good dash firmly, but to keep the balance for the next currents. But if you put a fault on the line, and let the charge leak out during the dead interval of the dash, then the next following negative current terminating the dash, would be too strong, so that an immediately succeeding positive current (with a negative current after it) to make a dot would miss fire altogether. Similar remarks apply to the dash. If the negative current that initiated the dash were allowed to die away by the action of a leak, the next following positive current would be too strong, and cause an immediately following current to miss fire. Remember that the reception of the signals was with a polarised recorder, the zero of which could not be continuously altered to catch the missing currents except by a very artful person who knew what was coming, and was quick enough to alter the regulation exactly at the right moments. It will, by the above, become roughly intelligible how a leak, actually quickening signals in a remarkable degree, can yet be most prejudicial in a special system of signalling requiring the preservation of a sort of balance. If the siphon recorder be substituted the necessity of the balance disappears; but the marks would be very hard to read at the same speed. To make them readable the speed should be at least doubled. The dashes will then become well-formed humps.

The reader who may desire to pursue the subject of leakage effects further may be referred to my "Electrical Papers," Vol. I., especially p. 53, for continuous leakage, p. 61 for more details relating to the above-described case, and p. 71 for the general theory of leaks, which is fully worked out in several cases to show the expediting effect. I also there propose artificial leaks. The following extract (p. 77) is easy to read, and so may be worth quoting:—

"When a natural fault, or local defect in the insulation, is developed in a cable, it tends to get worse—a phenomenon, it may be observed, not confined to cable-faults. Under the action of the current the fault is increased in size and reduced in resistance, and, if not removed in time, ends by stopping the communication entirely. Hence the directors and officials of submarine cable companies do not look upon faults with favour, and a sharp look out is kept by the fault-finders for their detection and subsequent removal. But an artificial fault, or connection by means of a coil of fine wire between the conductor and sheathing, would not have the objectionable features of a natural fault. If properly constructed it would be of constant resistance, or only varying with the temperature, would contain no electromotive force of polarisation, would not deteriorate, and would considerably accelerate the speed of working. The best position for a single fault would be the centre of the line, and perhaps ½ of the line's resistance would not be too low for the fault"

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The effect of one leak is marked, perhaps 40 per cent. What *does* this represent in £ sterling? How many thousands or tens of thousands of pounds' worth of copper and g.p., &c., would be equivalent? If one leak would not quite do it, then two would.

But to have only one or two leaks is to look upon the leak as a dangerous nuisance. Although the best position for a given amount of leakance *in a lump* is in the middle of the cable, yet to have the given leakance in a lump is the worst arrangement as regards its accelerative efficiency. The best arrangement is uniformly-spread leakance, as much as possible, with, however, a thoroughly useful residual terminal current to work with, which current could be varied far more rapidly than is possible with a single leak.

Is it impossible to find an insulator of comparatively low resistance which should be suitable in other respects? Telegraph cable manufacturers would probably say, No. That, however, need not be considered conclusive, because, as is well known, when an industry or institution is once established, it always gets into grooves, and has to be moved out of them by external agency, if at all. But should such an insulator be unattainable, then the only alternative is to have artificial leaks, as many as possible. The theory is, I think, quite plain, and I know that the practice is also, up to a certain point. But here be grooves again. For people working in established ways have their own proper work to do, and have no time to waste upon "fads." So much is this the case that it often happens that they have exceedingly little knowledge of how things would work out if they departed from the ruts they are accustomed to run along. That is to say, the spirit of scientific research, which was to some extent present in the industry in its early stages, has nearly all evaporated, leaving behind regular rules and a hatred of fads. I am no wild enthusiast, having been a practician myself, but it has certainly been a matter of somewhat mild surprise to me that cable electricians, who have had such unexampled opportunities in the last 20 or 30 years, say, should have done nothing in the matter of leaks. Perhaps there may turn out to be objections at present unthought of. The same could be said of anything untried. Several cases of resistance to change of established practice, where the changes ultimately turned out to be of great benefit, have come under my personal observation. The proposed changes were (I believe quite honestly) first scouted as fads, and the innovator was snubbed; next, under pressure, they were reluctantly tried; thirdly, adopted as a matter of course, and the innovator snubbed again. But this is the nature of things, and can be seen everywhere around—very notably in the political world.

(To be continued.)

THE HILL TESTING SWITCH.

A testing switch has been designed by Mr. Alex. Hill, of Hong Kong, for use more particularly on board cable repairing steamers and stations having to make frequent tests. The switch, as shown in the illustration and by the diagrams, gives instantly, by simply moving the lever, combinations for four tests constantly in use, and in its fifth position leaves the instruments disconnected, and ready to be joined up in any way the electrician pleases.

It will be seen in Fig. 1 that by means of the long lever handle, which is attached to the pivotted barrel, it is possible to throw the switch into several positions for the various tests; while, by means of the notches in the slotted plate shown in Fig. 2, the handle is firmly fixed in position. This slotted plate permits of two positions requisite for the Kennelly test, one each for the dielectric and copper resistance tests, and one for leaving the switch springs "free." On the barrel, which is turned round by the motion of the lever, there are three cams, which press against the switch springs and move them towards or away from the fixed contacts. The successive positions of the lever enable the circuit connections to take the forms shown in the Figs. 3 to 8. The quick change from, say, D R (dielectric resistance) to C R (copper resistance) is of great importance on a cable ship when time, owing to uncertainty of weather, is generally very scarce.

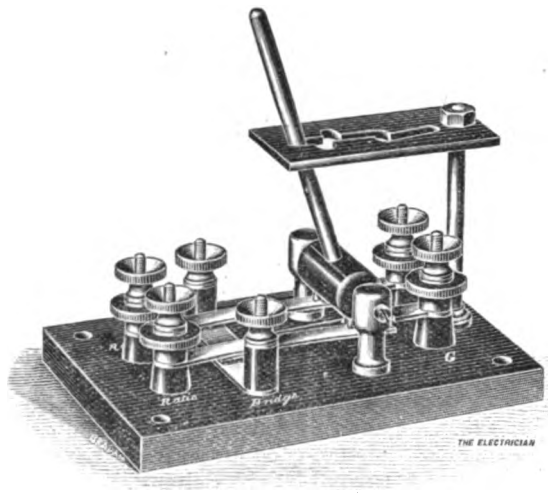

FIG. 1.—Hill's Testing Switch.

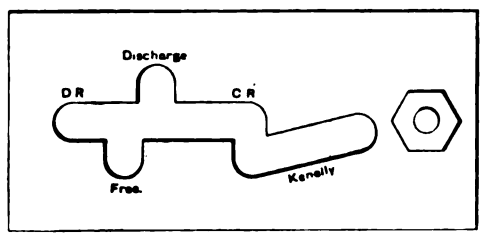

FIG. 2.—Plan of Moveable Slotted Plate

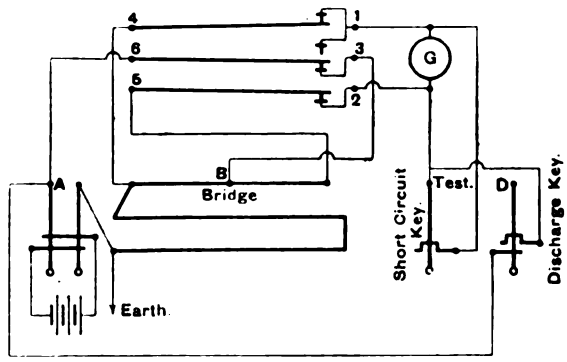

FIG. 3.—Complete Diagram of Connections for C.R. Test. The wire to be tested always goes on *Test Terminals*, except for Discharge Test, when Screw D of Discharge Key is used.

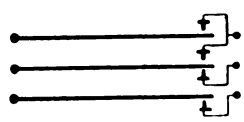

FIG. 4.—All Instruments Disconnected.

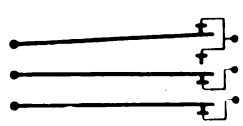

FIG. 5.—C.R. Test.

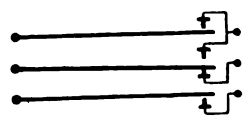

FIG. 6.—D.R. Test.

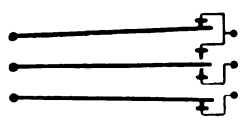

FIG. 7.—Resistance to be Inserted between A and B for Kennelly Test, Constant Current Blavier, &c.

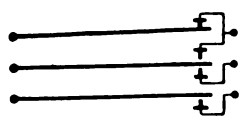

FIG. 8.—Discharge.

Several of these switches are now in use, one on board the Eastern Extension, Australasia and China Telegraph cable ship "Recorder," having been in use there for about three years. The instruments are made by Messrs. Muirhead and Co., London.

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AN EXAMINATION OF PROF. LODGE'S ELECTRO-MAGNETIC HYPOTHESIS.

BY PROF. J. H. POYNTING.

(*Continued from page 577.*)

The most evident phenomenon characterising the electric current is the magnetic field around it. This we may regard as manifesting the existence of so much magnetic energy in the neighbourhood of the conducting wire. Let us see how the hypothesis will account for this energy. The first step is to reduce permanent magnetism and current magnetism to one species by adopting Ampère's theory. If we consider a small closed current-bearing circuit, observation tells us that, at a distance from the circuit, the field is indistinguishable from that due to a small steel magnet, with centre in the plane of the circuit and axis perpendicular to it. Starting from this, we know that we can deduce an arrangement of permanent magnets, equivalent as regards the outside field to any current-bearing circuit. The circuit differs magnetically from the steel in two respects only, viz., that it requires a continual supply of energy to maintain it, and that we can get into its inside. This last difference may be merely due to the large size of any apparatus at our command, and it is quite thinkable that, if we could make ourselves or our apparatus smaller than molecules, we could explore the inside of the steel molecules. The other difference is possibly not one of the kind; for suppose the resistance to be diminished till it disappears, the rate of energy supply, C^2R, disappears also, and we have a current circuit—never mind how the current was started—which is as permanent a magnet as a steel bar. It is a short and inevitable step from this to Ampère's hypothesis that a magnetic molecule—a molecule of steel, say—*is* essentially a small closed perfectly-conducting circuit with a current of electricity in it; or, in terms of Dr. Lodge's hypothesis, either two equal and opposite currents whirling round at equal speeds in opposite directions in each molecule, or a positive whirl in one direction in one molecule, accompanied by a negative whirl in the other direction in the next molecule. We may dismiss this duality for the present, on condition that it comes up for sentence when called upon, and return to the single circuit. Such a circuit, when placed in a magnetic field, behaves, doubtless, like finite circuits, and tends to set itself perpendicular to the lines of force, and with its own lines parallel to the lines of the field, and in the same direction through the circuit. It tends to move from weaker to stronger parts of the field—tends, in fact, to include as many positive and exclude as many negative lines as possible.

But the disappearance of resistance has a peculiar effect Even a circuit of the resisting kind, with which alone we have practical acquaintance, would protest against the inclusion of foreign lines of force in addition to its own, and the current would diminish while they were being included. An ampere circuit would not merely protest, but would absolutely prevent any change in the total number included, for any increase would be accompanied by a finite negative E.M.F. proportional to the rate of increase, and therefore by an infinite current, since R is zero. This is not to be accepted as possible, so that all that can happen is that some of the current's own lines of force shall be replaced by those of the field, and there is a consequent weakening of the current.

When a mass of iron consisting, we suppose, of such ampere currents is brought into a magnetic field, all the circuits tend to turn round to include the lines of the field, and at the same time the ampere currents decrease in strength. The circuits thread themselves like beads on to the lines of force of the external field, their currents falling as they thread on. But their own surviving lines of force are added to those of the field, so that the total field is greater, and the iron has greater permeability than a vacuum; or perhaps it will be better here to say that the iron *conducts* the lines of force better than a vacuum would, for permeability has an exact significance, not quite describing the property now under discussion. As new lines of force are added to the field the iron will conduct them better than a vacuum, until every molecule has all its lines brought into service, and its current, therefore, reduced to zero. After this point is reached, since the molecules either will not take any more lines of force, or if they take any more will establish negative currents to neutralise them, they are worse conductors than a vacuum, for they fill up part of the space uselessly or injuriously. They will therefore tend to move from stronger to weaker parts of the field, as if diamagnetic. Some indication of such a change in conducting power has been detected by Ewing in the magnetisation of iron in exceedingly strong fields, for though the permeability or induction produced / the field producing it—both reckoned from zero—was always greater than 1, the value of increase in induction / increase in field producing it, or the conducting power, as I have called it, fell ultimately below 1.

For some reason, not yet explicable, the magnetic chains in iron become unstable, and break up when the temperature is raised to the neighbourhood of 800deg. The iron then is practically equivalent magnetically to any other substance above this temperature.

Assuming then that we have some notion of what we mean by currents of electricity whirling in channels of no resistance, Ampère's hypothesis gives us a fair explanation of iron and steel magnetism. If we accept the view that the interior of a magnet does not differ from the exterior in kind but only in degree and in permanence, we may attempt to extend the hypothesis to explain the magnetic qualities of all other substances, *i.e.*, their power of carrying the lines of force, and of carrying them in slightly different degrees.

Let us think of the lines of force in air circling round a current or passing from pole to pole of a magnet. We may think of these as passing through a number of electric whirls, or at any rate through perfectly conducting rings ready to exist as whirls. Before the passage of the lines of force these rings are turned in all directions. After the passage they tend to set perpendicular to the lines of force. If the medium is paramagnetic we may suppose the rings to have initial currents in them; if it is diamagnetic we may with Weber suppose that they have no currents initially, and when no lines of force pass through. On the establishment of the field negative currents are excited of such value as to make negative lines of force thread each ring equal in number to the positive lines sent through by the field. Thus each ring acts as a part of the field through which no lines of force pass, and the permeability is thereby diminished. At the same time the diamagnetic substance will tend to weaker parts of the field, and we have the main facts of diamagnetism explained. There is a serious difficulty in the nearly constant permeability, differing only by a very small amount for a diamagnetic solid like bismuth and a magnetic gas like oxygen, the one with its molecules crowded together, the other with its molecules comparatively wide apart. Perhaps we can strengthen this weak point by supposing the conducting rings of very different diameters in the two substances, or we may think of the electric channels as different altogether from the molecules and the same in number per c. c. in bismuth and in oxygen. Another difficulty lies in the non-existence of permanent magnetism except in iron, nickel, and perhaps cobalt, but it is no greater than the difficulty with iron above 800deg. Perhaps both will ultimately find the same explanation, and until this is forthcoming we need only say that Ampère's hypothesis is merely silent on the point and is not necessarily unable to explain it.

Now as to magnetic energy. Dr. Lodge points out a number of facts which suggest that magnetic disturbance is of the nature of spin round the lines of force. The amperean circuits at once present themselves as being the seat of this spinning, and the electric fluid or fluids in the channels as the spinning material. These whirlings of electricity, either in themselves or in the accompanying motion of the entangled matter (Maxwell, by the way, thought it was the matter), possess, according to Dr. Lodge, the magnetic energy of the system. In fact, they are themselves magnetism.

So far we have been dealing with magnetism and its relation to electricity, the space-filling fluid, and we have come to the conclusion that magnetism consists of vortices in this fluid. It remains to explain the nature of the ordinary electric

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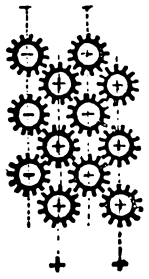
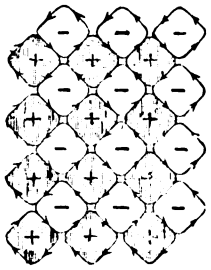
rrent, and the way in which its accompanying magnetic ld is maintained. Dr. Lodge uses for the purpose a echanical analogue or mechanical model, a modification of axwell's well-known model, which is described in his Scientific Papers," Vol. I., page 451, and I believe by Dr. arnett in "Maxwell's Life."



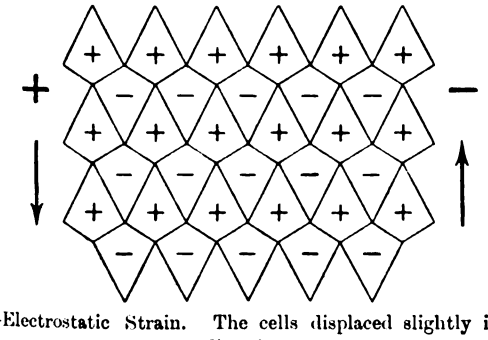
R. LODGE'S FIG. 36.—Rows of Cells Alternately Positive and Negative, geared together, and free to turn about fixed axes.

Let us imagine the two fluids, which are to be regarded as intly filling space, to have a cellular construction, each consisting of spheres or little india-rubber bags, or what you like, n contact with each other. In dielectrics we think of conguous cells as gearing in some way. Let these cells, when in magnetic field, be spinning round the lines of force, the ositive in one direction, the negative in the opposite; and et positive and negative be alternated so that the opposite notions may be possible without slip of gearing.



DR. LODGE'S FIG. 37.—Section of a Magnetic Field, perpendicular to the lines of force; alternate cells rotating oppositely. (Another mode of drawing Fig. 36.)

Fig. 37 from Dr. Lodge's book illustrates this idea when he lines of force pass into the paper from above, the axis f spin, therefore, being perpendicular to the paper. We may further materialise the conception by inserting teeth round the dges of the cells; and here the family likeness to the parent Maxwell's model) becomes stronger. We then have Fig. 36. If we suppose Fig. 37 to represent the unstrained state in a dielectric, then electrostatic strain will be represented by ome such deformation as that represented in the figure below

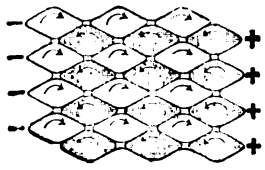


IG. A.—Electrostatic Strain. The cells displaced slightly in opposite directions.

Fig. A); not, I think, in the manner represented by Fig. 46 n Dr. Lodge's book.

If we take Fig. 36 as our type, it is easier to think of the wheels as being attached to some kind of framework. We may think of all the positive wheels in Fig. 36 as arranged lat against one series of parallel rods going down the page, and the negative wheels on another intermediate and parallel series. We may think of the wheels, or their teeth, as not quite rigid, so that when the positive rods are pulled down and the negative up, there is a slight relative displacement and energy is stored, and this will represent an electrostatic strain. Probably, if we arranged all the forces properly, we should be able to do without the framework of rods. Meanwhile I find I cannot think of the model clearly without it.

The distinction between a dielectric and a conductor is to be represented by the abolition of the teeth on the wheels in the conductor. The surface of the wheels are in contact, and are only more or less rough—viscously rough, rather than frictionally rough. It appears rather difficult to think of the layer of wheels separating a dielectric and a conductor, for on the dielectric side they must have toothed gearing, and on the conductor side they must only rub; but we may get over the difficulty by supposing these wheels double, one toothed to gear on the dielectric side, and the other untoothed to rub on the conducting side, and both keyed on the same axis.



DR. LODGE'S FIG. 46.

Dr. Lodge regards a current as represented by a slip of one row of wheels against the next. He says (p. 206), "Notice that in a medium so constituted and magnetised—that is, with all the wheel-work revolving properly—there is nothing of the nature of an electric current proceeding in any direction whatever. For, at every point of contact of two wheels, the positive and negative electricities are going at the same rate in the same direction; and this is no current at all. . . . A current is nevertheless easily able to be represented by mechanism such as that of Fig. 36 or 37; for it only needs the wheels to gear imperfectly and to work with slip. At any such slipping-place the positive is going faster than the negative, or *vice-versâ*, and so there is current there. A line of slip among the wheels corresponds therefore to a linear current. . . . Understand: one is not here thinking of a current as analogous to a *locomotion* of the wheels—their axes may be quite stationary. The slip contemplated is that of one *rim* on another."

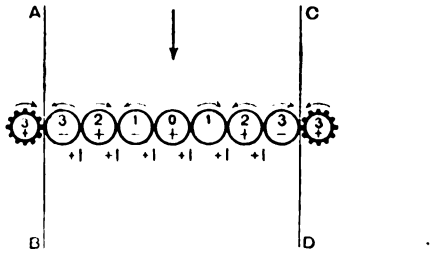


FIG. B.—Cells Slipping in a Wire carrying a uniformly distributed current.

Thus in the figure above (Fig. B), let the row of wheels represent the cells across the diameter of a wire carrying a steady current, A B C D representing the section of the wire. Let the speeds of rotation of the wheels be as marked on each. The resultant positive slip is +1 at each surface of contact, a total of 6.

It is perhaps presumptuous to quarrel with a parent such as Dr. Lodge as to his mode of developing the faculties of his own offspring, but I must venture here to differ from him entirely in the way in which he seeks to make his model represent current. It appears to me that he has grafted on to his own model the representation of current in the entirely different model of Fitzgerald, and so obtains something quite inconsistent with his previous ideas. It is only by stopping short at the centres of the bounding wheels that he can obtain a resultant flow in one direction. Obviously, if he took in a whole number of wheels, each entire, he would get no resultant flow, for the flow on the opposite sides of each wheel is equal and

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opposite. Thus, in the figure, if he took into account the outer sides of the two last wheels in the wire, he would have −6 neutralising the previously obtained +6. Or, to put it in another way, if we draw a plane, say, above the line of centres, a tangent to all the wheels, there is evidently no resultant flow across that plane. And we can think of cases of slip when we have no reason to suppose there is current. Thus, if a bar of soft iron is placed axially in a magnetic field near the centre of the bar the lines of force are parallel to its length within and without the bar. According to Lodge, the electric whirls are very rapid within the iron, and comparatively slow in the air outside. There must, therefore, be slip at the boundary, and yet we have no dissipation of energy to indicate the existence of the current.

Another objection is that the model worked thus would make a difference in kind between the process of displacing in a dielectric, the equal and opposite motions of the two fluids which are leading to an electrostatic strain, and the current in a conductor. This is rather setting back the clock. Perhaps we have gone on too fast, and the difference *may* exist, but I think we should hardly accept the evidence of the model on the point.

What Prof. Lodge calls current appears to me then to be merely sudden change of magnetic intensity. If this is just criticism let us see if the model can be made to represent a true current. I shall take the case of a steady current in

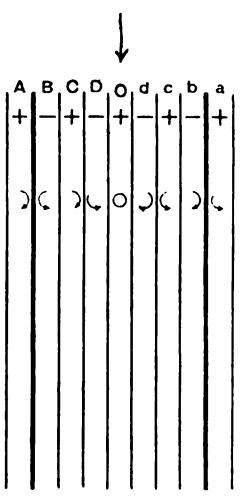

FIG. C.—Rods on which the positive and negative wheels are supposed to be fixed in the model of a wire carrying a current.

which the condition of affairs is not altering. It is always better to begin with such a case, just as it is better to begin with statics, hydrostatics, electrostatics, than with dynamics, hydrodynamics, and electrodynamics. When matters, or ethers, get into changing motion they are like the celebrated pig of the Irishman, difficult to count.

In the model we shall suppose that the current in the wire is represented by two equal and opposite processions of cells or wheels along the wire, and to help us in thinking of these processions we shall, as before, suppose two sets of rods parallel to the axis of the wire, the positive wheels on one set with their spindles perpendicular to the rods, and the negative wheels on the other set.

In the figure above (Fig. C) the rods alone are represented, directions of motion of the wheels on each being shown by arrows. The + rods are to be regarded as moving down the page, and the − rods up. The wheels on the bounding rods, B *b*, gear with the wheels on A *a* in the dielectric, but slip on those on C *c* in the conductor. Now, if the conductor extended through all space I do not see that the motions of the rods would involve rotation of the wheels. For any rod would be as it were surrounded by a symmetrical system, its wheels would not know which way to turn, and so would merely rub against their neighbours. But here the conductor is bounded by an insulating medium in which the rods can only move a very little way, and that only by straining the teeth of the wheels.

The result is that as B moves up past A its wheels behave as pinions moving on a rack in the place of A. They tend to turn the wheels of C in the opposite direction. These in turn tend to send round the wheels of D, and so on to O, the middle rod. Now, starting from the other side, *a* is at rest, and as *b* moves past it its wheels must rotate. This rotation is transmitted inwards, as before, to O. The result is that the wheels on O are urged in opposite directions from the two sides, and so remain at rest, while those of D and *d* rub against them. Those of C and *c* rotate faster than those of D and *d*, the friction due to the slip balancing that due to the slip of D and *d* on O, and so on, the rotation increasing outwards. When we come to B *b*, their wheels have the frictional resistance against the C *c* wheels on the inside, which must be balanced—since the motion is steady—by pressure on the outside against the A *a* wheels. Hence the B *b* wheels are not merely rolling on the A *a* wheels, but are pressing against them, and so turning them round. In other words, the rotation extends out into the dielectric. Thus, at the middle of the wire, there is no rotation—no magnetic intensity. It increases as we go outwards to the boundary, being in opposite directions on the two sides, and it exists in the surrounding medium. The rubbing of the surfaces, perhaps of the rods, perhaps of the wheels, dissipates energy which represents the heat appearing in the wire.

The model is probably indeterminate as to the way in which the energy finds its way into the various parts of the conductor, where it appears as heat. We might imagine the rods moved by end thrusts along the wire, their wheels setting the outside wheels spinning, or we might imagine a spin propagated along the outside wheels to the wire, and there setting the rods in longitudinal motion.

I have no doubt that the model would be able to represent the phenomena of the current induction when the motion is accelerating or unsteady, for Maxwell's model does this, and the differences of construction would hardly affect the point.

(To be concluded.)

THE APPLICATION OF ELECTROLYSIS TO QUALITATIVE ANALYSIS.*

BY CHARLES A. KOHN, PH.D., B.SC.

The first application of electrolysis to chemical analysis was made by Gaultier de Claubry in 1850, who employed the electric current for the isolation of poisonous metals, using platinum electrodes on which the deposition of the metal took place.

Other early workers followed in this direction, and in 1861 C. L. Bloxam published two Papers on "The Application of Electrolysis to the Detection of Poisonous Metals in Mixtures of Organic Matters" (*Jour. Chem. Soc.*, 13, 12, and 338). The author appears to have made extensive use of the methods described in these papers, and which have reference to the detection of arsenic, antimony, mercury, bismuth, and copper. The electrolysis was effected in acidulated solutions, from which the arsenic was evolved as hydride, whilst the other elements were deposited in the metallic state upon the cathode and subsequently tested, after dissolving, by the usual reactions.

Since the publication of these results the advances in electrolytic analysis have reference to quantitative methods only and the advantage of these latter for qualitative work has been, to some extent, overlooked. Within the last twelve years Classen and his pupils have placed a number of electrolytic methods for the determination and separation of metals in the hands of chemists, methods which have been added to by the labours of E. F. Smith, Vortmann, and others. These methods are of special value when applied to qualitative analysis in cases of medical and of medico-legal inquiry. They are not supposed to supersede in any way the ordinary methods of qualitative analysis, but to serve as a final and crucial means of identification and thus render it possible to detect very small quantities of the substances in question with great accuracy. As such they fulfil the required conditions admirably, being readily carried out, comparatively free from contamination with impure reagents and capable of being rendered approximately quantitative whenever desired.

The method devised by Bloxam for the detection of arsenic, in which all fear of contamination with impure zinc is avoided, has

* Paper read before Section B of the British Association.

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been elaborated by Wolff (*Jour. Soc. Chem. Ind.*, 1887, p. 147), who has succeeded in detecting 0·00001grm. of arsenious acid by this means. It is in connection with the most important of the remaining mineral poisons that I have examined the applicability of these electrolytic methods, viz., antimony, mercury, lead, copper, and cadmium.

Antimony.—The method employed in the case of antimony is that adopted in its quantitative estimation by means of electrolysis, a method which ensures a complete separation from those metals with which it is precipitated in the ordinary course of analysis, arsenic and tin. This fact is of considerable importance in reference to the special objects for which these methods have been worked out.

The precipitated sulphide is dissolved in potassium sulphide, and the resulting solution, after warming with a little hydrogen peroxide to decolourise any polysulphides that may be present, electrolysed with a current of 1·5-2cc. of electrolytic gas per minute (10·436cc. at 0°C. and 760mm. = 1 ampere) when the antimony is deposited as metal upon the negative electrode. One part of antimony (as metal) in 1,500,000 parts of solution may be thus detected, a reaction thirty times more delicate than the deposition by means of zinc and platinum. The stain on the cathode, which latter is best used in the form of a piece of platinum foil about 1cm. in diameter, is distinct even with a solution containing $\frac{1}{20}$mgrm. of antimony, and by carefully evaporating a little ammonium sulphide on the foil, or by dissolving the stain in hot hydrochloric acid and then passing a few bubbles of sulphuretted hydrogen gas into the solution, the orange-coloured sulphide is obtained as a satisfactory confirmatory test. The detection of 0·0001grm. of metal can be fully relied on under all conditions, and one hour is sufficient to completely precipitate such small quantities.

Mercury.—Mercury is best separated from its nitric acid solution on a small closely-wound spiral of platinum wire. The solution to be tested is acidified with nitric acid and electrolysed with a current of 4-5cc. (cc. refer to cc. of electrolytic gas per minute). The deposition is effected in half an hour. The deposited metal is removed from the spiral by heating the latter gently in a test-tube, when the mercury forms in characteristic globules on the upper portion of the tube. As a confirmatory and very characteristic test, a crystal of iodine is dropped into the tube, and the whole allowed to stand for a short time, when the presence of mercury is indicated by the formation of the red iodide. 0·0001grm. of mercury in 150cc. of solution can be clearly detected.

Wolff has applied this test under similar conditions, using a special form of apparatus through which the solution to be tested is allowed to pass slowly, and in which a silver-coated iron electrode is employed as the anode.

Lead.—Lead is precipitated either as PbO_2 at the anode from a solution containing 10-20 per cent. of free nitric acid, or as metal, at the cathode, from an ammonium oxalate solution. In both cases a current of 2-3cc. suffices to effect the deposition in one hour.

Here again 0·0001grm. of metal in 150cc. of solution can be easily detected. With both solutions this amount gives a distinct colouration to the platinum spiral on which the deposition is best effected. As a confirmatory test the deposited metal is dissolved in acid, and tested with sulphuretted hydrogen, or the spiral may be placed in a test-tube, and warmed gently with a small crystal of iodine when the yellow iodide of lead is formed. The latter reaction is very distinct, especially in the case of the peroxide.

Of the above two methods that in which an ammonium oxalate solution is used is the more delicate, although it cannot be employed quantitatively owing to the oxidation that takes place on drying. An addition of 1grm. of ammonium oxalate to the suspected solution is sufficient. A great advantage of the electrolytic method as a crucial means for the detection of minute quantities of lead, lies in the fact that when the lead is deposited as peroxide from a nitric acid solution, it is completely separated from mercury, copper, cadmium, arsenic, antimony, and iron, none of which are deposited at the anode in this case. Manganese is the only commonly occurring element that behaves similarly.

This method is therefore of value for the detection of lead in water, citric and tartaric acids, baking powders, &c. If quantitative results for small quantities of lead are required, the best plan is to effect the electrolysis in nitric acid solution as above, employing a small platinum dish as the anode, to which the deposited peroxide, adheres well, and which can be weighed as PbO_2 after washing and drying at 110°C. May has suggested (*Z. f. Anal. Chem.* 14, 347) the ignition of the PbO_2 to PbO, and final weighing of the latter, but a loss always occurs under these conditions, which increases with the quantity of the peroxide present. This loss amounts to 2-3 per cent. on the weight of lead deposited.

Copper.—0·00005grm. of copper can be very readily detected by electrolysing an acid solution in the usual way. A spiral of platinum wire is employed as the cathode, and the presence of the metal confirmed by dissolving it in a little nitric acid and testing with potassium ferrocyanide. Quantitative results in solutions containing 0·001grm. of metal are thus obtained with considerable accuracy, and the method, as in the case of lead, is of use for the detection of minute quantities of the metal in waters. The advantages of electrolysis over the colorimetric methods usually employed in such cases are twofold. In the first place, concentration is not necessary, owing to the delicacy of the test; and secondly, the erroneous results that are obtained in all colorimetric processes due to the influence of the varying constituents present in the solution tested on the accuracy of the reaction are entirely obviated.

Cadmium.—Cadmium is deposited in the metallic state, both from potassium cyanide and from potassium oxalate solutions, the former of which is preferable. A current of 0·2cc. is sufficient, and 0·0001grm. of the metal can be thus detected. To confirm, the deposit is dissolved in hydrochloric acid, the solution diluted, and treated with sulphuretted hydrogen.

Detection of Metallic Poisons in Urine by Means of Electrolysis.—To apply the above methods in cases of poisoning, the organic matter with which the metals are associated must first be destroyed in the usual way by means of hydrochloric acid and potassium chlorate, and the solutions or precipitates obtained in the ordinary course of analysis then subjected, at suitable stages, to electrolysis. In such cases the advantages of electrolysis lie again in the delicacy and reliability of the tests and also in the fact that the small quantities of organic matter, with which the solutions obtained in such cases are contaminated, do not interfere with the electrolytic tests as they do with the ordinary wet tests By passing the current for a longer time than is required for ordinary aqueous solutions, the organic matter is decomposed, and thus prevented from affecting the reliability of the tests.

The detection of metallic poisons in urine can be directly affected by electrolysis.

The presence of *mercury* or of *copper* is detected by acidifying the urine with 2-3cc. of nitric acid (conc.), and electrolysing as described. 0·0001grm. of metal can be detected thus in 30cc. of urine, or 1 part in 300,000 of urine.

Lead does not separate well as peroxide from urine acidified with nitric acid, but if ammonium oxalate be added the reaction is quite as delicate as in aqueous solution, and 0·0001grm. of lead can be thus detected.

Antimony can be detected directly in urine, according to Chittenden (*Proc.* Connecticut Acad. of Science, Vol. VIII.), by electrolysis after the addition of 2-3cc. of dilute sulphuric acid; but this process was not found satisfactory. The better plan is to first precipitate by sulphuretted hydrogen, and then electrolyse as described.

In all these cases it is necessary to pass the current at least twice as long as when aqueous solutions are employed. In 24 hours a current of 1-2cc. completely decomposes urine, leaving a clear colourless solotion.

A comparison of the delicacy of these tests with the ordinary qualitative tests for antimony, mercury, lead and copper, by means of sulphuretted hydrogen, showed that in the case of antimony and of copper the electrolytic tests were one and a-half times more delicate, whilst with mercury and lead they were at least ten times more so. These comparisons were made in aqueous solutions.

In testing urine the value of the electrolytic method is still more evident, for the colour of the liquid interferes materially with the reliability of the ordinary qualitative tests when only small quantities of the elements referred to are present. This was well instanced in a case of suspected lead poisoning, in which the patient had been treated with potassium iodide. A direct test with sulphuretted hydrogen gave no reliable result even after standing 24 hours, whilst the deposit obtained on electrolysis gave a distinct *precipitate* of lead sulphide, after being dissolved in acid.

Other applications of the more reliable electrolytic methods of analysis to qualitative work can only offer attraction in special cases, and the data on the subject are to be found in the many electrolytic methods already published. It is by their judicious combination with the ordinary methods of analysis that a saving of time and labour and, above all, an increased reliability and accuracy are effected.

Split Car-Axles on Electric Cars.—There is, says *The Engineer*, a new electric car motor in process of construction in Chicago, which has two armatures so arranged that they may revolve at two different speeds, the fundamental idea at the basis of this peculiar construction being to secure a more ready and easy method of taking curves on street railways with the two armatures, it being found that the speeds are differentiated according to the radii of the two rails on every curve. The varying speed of the wheels on the outer and inner rails will, it is intended, do away with the friction incidental to the usual method of both wheels revolving at the same speed round the very sharp curves found on street railways.

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MANCHESTER.

It is seldom that an opportunity can occur for the erection of so large a supply station as that which we describe elsewhere in our present issue. Manchester will profit, not only in the long run, but in the immediate future, by the deliberation with which an electric supply has been established. No straggling overhead system of wires had to be pulled down and written off, no inadequate attempts of speculative pioneers were to be bought up and shut down, nor has the City been divided up into arbitrary districts among competing companies. The early proposals were, however, more sound than was often the case seven or eight years ago. In 1886 the Manchester Electric Supply Company was founded "to light streets, public places, mines, ships, railways, tramways, or any other places or things by means of electricity or other similar agency; to create or produce electricity or other similar agency," &c. The Directors were Messrs. CROMPTON, ALBRIGHT, HOLMES, and VAUDREY. During the next year the highly successful exhibition was held at Manchester, and it might have been expected that the fine display of electric lighting, both in the buildings and in the gardens, would have borne some fruit in the lighting of the City. Messrs. MATHER and PLATT showed two 200 H.P. engines, each driving a pair of "Manchester" dynamos by link belts and jockey-pulleys, and the Brush Company provided nearly 600 arcs, some on masts in the grounds; and besides these were many other machines, good and bad. The only apparent result was the lighting of the Victoria Hotel, in 1888, by Messrs. HOLMES and VAUDREY, a hotel being a "place or thing" not otherwise specified in the prospectus of their Company. In the course of 1889 the Manchester Edison-Swan Company began to bestir themselves, and proposed to put down plant near Piccadilly for 10,000 lights. But the City Council had probably been watching developments, and because they owned the gasworks, rather than for modern socialistic reasons, which in themselves would have violated the recognised principles of the Manchester school of political economists, met to consider the question of a Provisional

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Order in the summer of 1889. The Gas Committee offered no objection; and the Council discussed the serious prospects, on the one hand of compulsory lighting of an area, and on the other, of the action of the half-dozen companies who were already in the field, and who would scramble for an Order if the Council did nothing. The Mayor pointed out that the risk was not immediate; they had three years to turn round in, and were not obliged to commit themselves. The Order was obtained in 1890, and in the following year the Gas Committee appointed Dr. J. Hopkinson to draw up a scheme.

Although the five-wire system adopted by the engineer is the first example of its kind in this country, there is but little novelty about it. The possible demand for power might have resulted in a multiphase complication; or sub-stations with wonderfully ingenious automatic switches might have been tried. There will, of course, be many who would have liked to have seen alternate currents of some sort, and others will think the scheme only wants £25,000 worth of batteries at the station or in sub-stations, to make it perfect. One of the most striking features of the present state of the Manchester municipal power station, and one which a visitor cannot fail to notice immediately he enters the buildings, is the ample amount of space which has been arranged for extension of every department of the generating plant. In the vast machinery hall, the floor of which is even now completely roofed over, and which is provided with travellers throughout its entire length, there is space for about three and a-half to four times the present capacity of plant, and from ten to twelve times the present maximum of lamps. In the boiler house there is room for a considerable number of additional boilers; and by filling up an arm of the canal and building over the flooring thus acquired it will be possible to set a still greater number. The conduits, in like manner, have been constructed to take several extra feeders, while the copper which is already laid can carry a much greater current before its most economical current density is reached. Thus there would seem to be no prospect of the unhappy experience at some generating stations being repeated at Manchester, namely, of its becoming "pot-bound"—of its load increasing beyond the proper limits of its possible plant. There can be no doubt as to the wisdom in this particular case of such a high "factor of safety" for extensions as has been adopted in Manchester, even though the amount of capital which must be sunk in unremunerative works may be rather larger than is customary. For Manchester is certainly very late in its adoption of electric light and power; it is behind every leading city in the world in this respect; in fact, it is almost behind the proverbially trailing Bristol. Yet there can be no doubt that, the supply once offered, the citizens of Manchester will not be slow to avail themselves of it; and that, for some time to come, the engineers will find themselves very busy with new consumers. Situated as the power station is, in the midst of a manufacturing district, it is a matter for some surprise that, although some ten thousand lamps are already connected, there has been no demand whatever for motors. But for the similar apathy in London and elsewhere, one would have expected that attractive terms would have been offered to supply, if not factories, at all events small workshops with power during the day.

Into the vexed question of comparative merits of continuous and of alternating currents we need not now enter, nor will we urge that 410 volts is a step towards the adoption of high pressure supply as distinguished from low pressure, but we must express our great regret that, according to a scheme which has been submitted to the Local Government Board, it is proposed to provide an alternate-current supply for Salford. The two districts have long had their separate gas supplies; but with gas plant the load factor and its characteristics are of small importance, since storage is so easy and efficient. Still, that is no reason for the irrevocable separation which will be entailed if different systems are adopted. It is probable that the loads in the two districts will be materially different, and considerable benefit might result from a co-operation between them. The whole of the two areas would be none too large for a single system with two stations working together like those of the Westminster Company. The different London districts are ridiculously small, and this is due to the keen competition among the companies who were represented before Major Marindin. They were formed for the most part round scattered stations already existing, but in the course of time many combinations will doubtless be made either for the purpose of occasional co-operation, or for some comprehensive system of distribution of power generated at a distance. The station at Manchester is on an altogether different scale from these; and it may be expected that the Corporation will not only have reason to be proud of their electric supply, but will be able to show high economy in working expenses.

THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 584.)

Great care should be taken with the measuring instruments to see that they are correctly calibrated and can be relied upon all over their scales.

In measuring the power taken by a lamp with an ammeter and voltmeter certain precautions are necessary. If the voltmeter is connected directly to the lamp terminals, so as to indicate the volts on the lamp, the ammeter must of necessity be connected so as to measure the current through the lamp plus that through the voltmeter. On the other hand, if the ammeter is connected so as to measure the current of the lamp only, the voltmeter must be connected to measure the difference of potential over the lamp plus the ammeter. In the former case there will be an appreciable error, unless the voltmeter has a very high resistance compared with that of the lamp, and in the latter case there will be an error unless the resistance of the ammeter is so small as to be negligible in comparison with that of the lamp. Instruments can be made of such resistances that in either method of connecting the error is negligible.

A wattmeter may be regarded as a combination of a voltmeter and an ammeter, and is therefore liable to errors from the same cause. The resistances of the wattmeter cannot, however, be well made of such amounts that the error is negligible. It therefore becomes necessary to compensate for the error. This may be done by means of a double winding on the current coil, each winding having the same number of turns. The pressure coil of the wattmeter is connected directly to the terminals of the lamp. The lamp current plus the current through the pressure coil, therefore, passes through the main winding on the current coil of the wattmeter. The current through the pressure coil alone is, however, taken through the supplementary winding on the current coil in the reverse direction. The current of the pressure coil thus traverses the current coil an equal number of times in opposite directions, and its effect is, therefore, neutralised, and the instrument gives a correct reading of the power spent in the lamp. In order that the wattmeter shall have as wide a range as possible the current coil may be again wound in two equal

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windings, which can, by means of a switch, be connected up either in series or parallel. This arrangement necessitates the compensating winding being wound in two sections in the same way. There are therefore really four windings on the current coil.

Fig. 36 is a diagram of the connections. P is the wattmeter pressure coil. C C is the main current coil. K K is the compensating current coil. The two parts of these coils can be respectively connected in series or parallel by the switches S_3 and S_4. L is the lamp under test and l is the subsidiary lamp which is switched on by the switch S_2 for the purpose already explained, when the lamp L is being changed. R is the variable resistance, and S_1 is the main switch. V is the voltmeter, and A the ammeter. It will be noticed that the voltmeter current, as well as that through the pressure coil of the wattmeter passes through both the windings of the current coil of the wattmeter, and its effect is therefore neutralised.

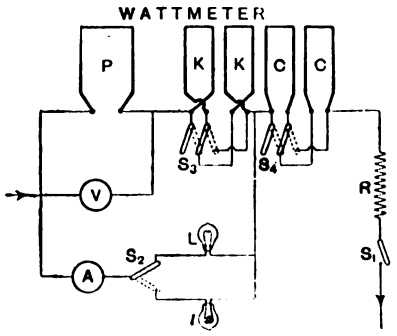

FIG. 36.

If an ammeter is used it may be placed where it is shown in the diagram, provided that it has a resistance extremely small compared with that of the lamp under test. If, however, its resistance is not very small it must be connected so as to take the whole of the current, including that of the voltmeter and the wattmeter pressure coil. In this case it should have a double winding, precisely as the current coil of the wattmeter, so that it indicates only the current through the lamp.

In a wattmeter constructed on the above lines by the author most of the high resistance wire was wound on the suspended coil, which was consequently heavy, and required a vane moving in glycerine in order to damp its oscillations. Mr.

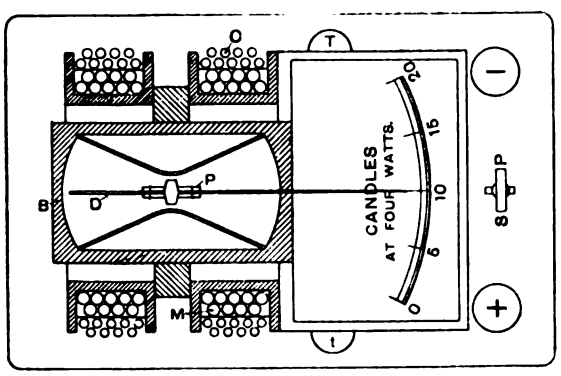

FIG. 37.—Sectional Plan of Evershed's Wattmeter.
(For reference letters *see* Fig. 39.)

Evershed has designed a wattmeter for lamp testing of a more delicate construction, the suspended coil being very much lighter than in the instrument the author has used. By the courtesy of Mr. Evershed the author is able to give the accompanying sketches of the instrument, Figs. 37 and 38. Fig. 39 is a diagram of the connections which are similar to those in Fig. 36. There are two small pressure coils P P., one on each side of an aluminium vane D. This vane fits the vane box B only very loosely, but it is so large and light that the air damps out the oscillations in about two seconds. The bifilar suspension F passes over a pulley at the top. In this way it is ensured that the strain is equally divided. The suspension is silk where it passes over the pulley, but just below the pulley it is wire, and serves to convey the current to the coils P P. Fine wires lead the current to and from the suspension wires at their junction with the silk. In series with the pressure coils P P is a platinoid resistance, R, situated in the base of the instrument. M is the main current coil, and C is the compensating coil for the current through the pressure coil and the voltmeter. T is the terminal of the

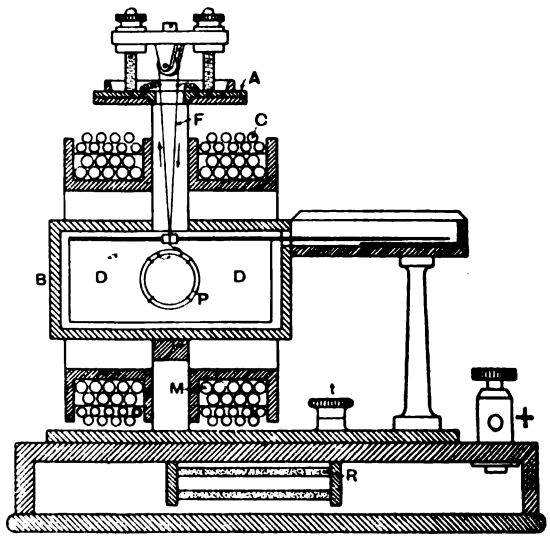

FIG. 38.—Sectional Elevation of Evershed's Wattmeter.
(For reference letters *see* Fig. 39.)

pressure coil circuit, t is the terminal for the voltmeter. The main terminals are marked + and −. A is a plate carrying the pulley, and is capable of rotation for adjusting the zero. S P is a switch for coupling the coils M M and C C respectively in series or in parallel, and so obtaining a double range. V is the voltmeter, and L is the lamp under test. I is the index of the instrument. This arrangement of the index and scale is not good for rapid testing in the manner already described, as the observer at the photometer has to turn away from the photometer in order to read the instrument which must be placed on one side so that he can look down upon it.

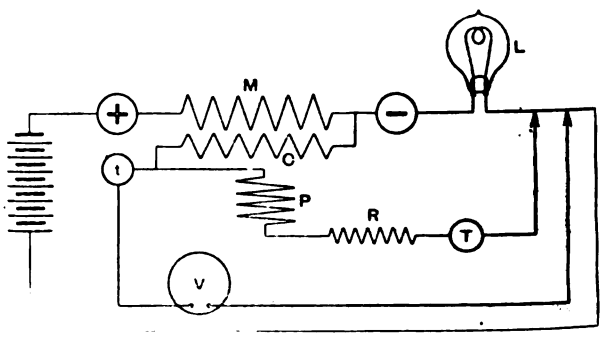

FIG. 39.—Diagram of Connections of Evershed's Wattmeter.

+ −, Main Terminals; T, Terminal of "Pressure" Coil Circuit; t, Terminal for Voltmeter; M, Main "Current" Coils; C, Compensating Coil for Pressure Coil and Voltmeter Current; P, Pressure Coils, in Series with Platinoid Resistance R; D, Vane Box for Damping Oscillations; D, Aluminium Vane to which P P is fixed; F, Bifilar Suspension, serves to lead Current into P P; A, Plate carrying Pulley and capable of Rotation to adjust Zero; I, Index; S P, Switch to couple M M and C C in Series or in Parallel and obtain double range; V, Voltmeter for Measuring Pressure on Lamp Terminals; Lamp under Test.

The method of compensating the wattmeter and ammeter for the error due to the voltmeter current was devised by Mr. Swinburne.

For laboratory testing, where speed is not so important, it is sufficient to test with an ammeter and voltmeter only. The ammeter, if of an appreciable resistance, should be connected so as to measure the current through the lamp, plus the voltmeter current. A table of the voltmeter current for each volt can be hung up in a convenient place, and the amount can be deducted from the ammeter reading at once.

(To be continued.)

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MANCHESTER MUNICIPAL ELECTRIC POWER STATION.

The event which took place on Saturday and Sunday, September 23rd and 24th, of the transference of the whole of the lamps on the Manchester electric power mains from the temporary two-wire 100-volt arrangement, on to the regular five-wire 400-volt system, for which the mains and generating machinery have been designed, may be said to mark the point at which this station passed from its incipient stages into the full-grown activity of adult life. Not that the station is as yet completed, for ample allowance has been made in building for that extension of plant which is bound to result from the introduction of electric light and power into so populous and industrial a centre as Manchester city; and the spacious machinery hall is but one-fourth filled, or the extensive space allotted to boilers is as yet only partially roofed over. Nor even that the existing plant is quite fully loaded; although some ten thousand glow lamps were on the mains at the time of the transference to the regular system.

The system of distribution and the generating plant have been constructed to plans designed by Dr. J. Hopkinson, consulting engineer to the Corporation. In general it may be described as the continuous-current, five-wire, direct-feeder system; although ultimately the network of mains may require to be fed at the most distant points by means of continuous-current transformers. The principle of this system is indicated by Fig. 2. The five parallel lines, a, b, c, d, e, represent the distributing mains, between each adjacent pair of which there is a pressure of about 100 volts, to which the house service mains are connected as required, as shown at x and y.

The outermost mains, a and e, are of sufficient section to take the whole load at the 400 volts pressure which is maintained between them, this load being determined by the distance apart of the feeding points. But the inner mains, b, c, d, constitute balancing wires, the purpose of which is to carry the outgoing or return current due merely to the difference of loads on the two sections on either side of them; they are, therefore, of smaller sectional area. This system of five wires, which is carried throughout the entire area supplied with power, is fed at a number of points—the number is eight at present—by means of several pairs of feeders, as at f_1 and f_2, which are supplied with power from large 410-volt dynamos, D. Besides the power derived from these, the mains receive power from the balancing dynamos, 1, 2, 3, 4, which are placed directly on the several sections of the five-wire mains, and are not coupled to the feeders. It is the function of these smaller generators, which are run at the pressure of each section, to balance the load between any two adjacent pair of sections. Since great care is taken so to dispose the load that the difference between the loads on any two sections shall be but a small fraction of the whole load, it will be evident that these balancing dynamos need not be very large. The Manchester mains are partly composed of bare copper strip, supported by porcelain insulators, and set in spacious concrete conduits, and partly of Silvertown

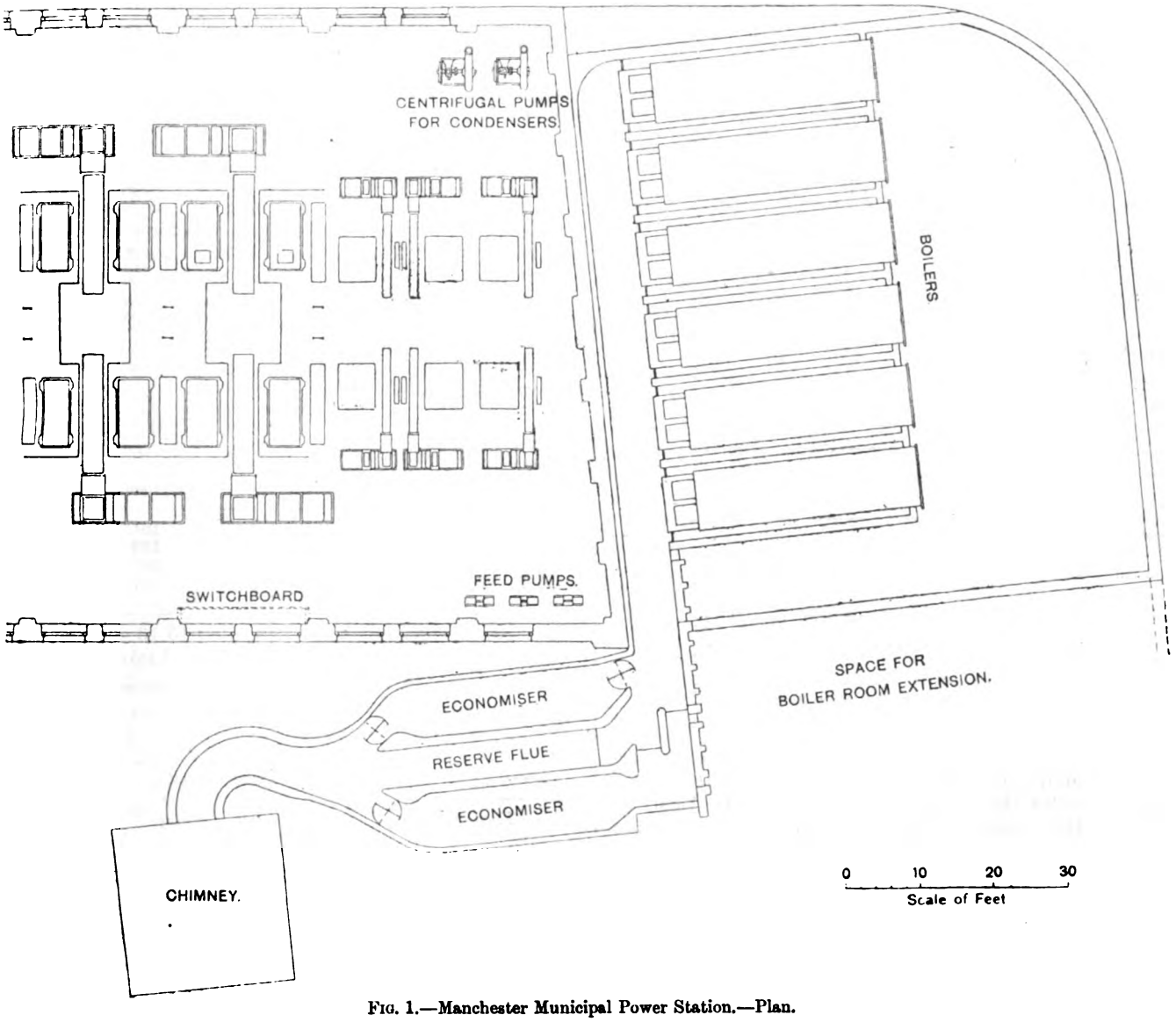

FIG. 1.—Manchester Municipal Power Station.—Plan.

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covered cable. The former kind of main is at present most commonly used, both for the various feeders and for the five distributors; but flexible covered cable, laid in cast-iron conduits, is entirely used in carrying the current under roadways, owing to the brittle nature of the bare-wire system. This, of course, necessitates a draw-box at each side of every street crossing, which involves a considerable number of main joints per mile run of conduit where the streets are dense. The drawing-in system can only be employed where covered flexible cable is used, and the conduits for the bare strip conductors are placed under the footpath. These latter conduits are provided with a slight fall towards the surface boxes, at each of which they are drained into a well, which is trapped on to the street sewers.

In order to maintain the conduits in as dry a state as possible a draught of air is circulated continuously through them by means of a fan propelled by an electromotor at the station. In the event of any section of the culverts becoming very wet, it is arranged that this ventilating plant can be temporarily removed to the nearest surface box, where it can be clamped into place and run from the bare mains. It should be remarked that, in general, the mains are of bare strip wherever the section exceeds four square inches.

The large dynamos for supplying power through the feeders are designed to run at 400 revolutions per minute, each machine giving 590 amperes at a terminal pressure of 410 volts. Two of these manufactured by the Electric Construction Company on the lines of the well-known Elwell-Parker designs, are now running, and others by this firm are to be erected shortly. Machines of similar output, manufactured by Messrs. Mather and Platt on the Edison-Hopkinson design, are also to be

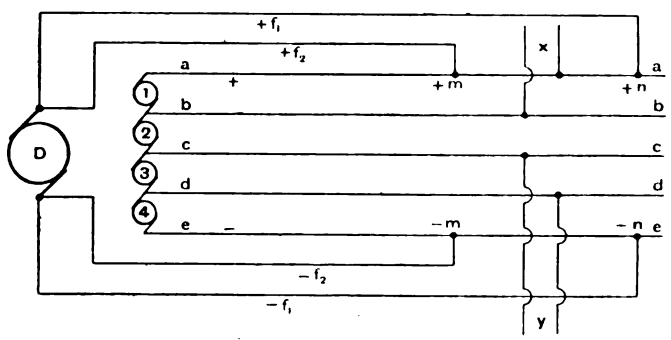

FIG. 2.—Manchester Five-Wire System.

erected, and two of these generators are now running. The engine and dynamo room is designed for 14 of these large dynamos, besides the six smaller distributing or balancing machines. These latter are also Elwell-Parker dynamos, manufactured by the Electric Construction Company, and are designed to give 590 amperes at 102 volts, at 540 revolutions per minute.

The 60-kilowatt machines are of the usual two-pole type, having a single magnetic circuit. They possess an improvement lately introduced into the Elwell-Parker machines which enables the armature to be easily and quickly examined or removed without removing the pedestals and drawing the armature through the magnets. This is attained by cutting the pole pieces in a slanting direction to a height a little above the centre of the armature; these two removal pieces are bolted to a brass grid, and when raised leave half the armature exposed; it can then be easily lifted out in event of an accident. They are fitted at each bearing with patent lubricating pumps. The 240-kilowatt machines are of the double magnetic circuit type, and are also provided with pump lubricators.

One of the stipulations of the contract was that the efficiency of the dynamos should be carefully tested by coupling two similar machines, one acting as motor and one as dynamo, the dynamo restoring the power generated to the motor, the excess required to overcome the losses in the system being supplied by a third machine, the magnetising power being supplied from a separate source. The efficiency was taken as the ratio between the watts generated by the dynamo (measured as its terminals) less the watts required to magnetise, to the watts delivered to the motor plus the watts required to magnetise, or if

D = watts at dynamo terminals,
M = watts at motor terminals,
M_1 and M_2 the watts required to magnetise the dynamo and motor and motor respectively,

then the efficiency = $\frac{D - M_1}{M + M_2}$.

It was decided in the case of the Elwell-Parker machines to couple the machines together by means of belts and sacrifice the loss in the belts rather than make special arrangements for bolting the two armatures together by means of prolonged shafts and special couplings. The 60-kilowatt dynamos were run for six hours. During the last hour readings of the current and voltages were taken. The final result gives an efficiency of 84·5 per cent.; this, of course, included loss in the belt, which was double leather 9in. wide, or an efficiency of each machine of 92 per cent. The armature resistance was 0·00319 ohm when hot, and the field-magnets under similar conditions 9·26 ohms, from which figures it follows that the loss in the armature is the same as that in the F.M. coils, each being 1·85 per cent. of the output. This leaves about 8 per cent. in the combined system to be accounted for by hysteresis, friction, and belt loss; allowing a 2 per cent. loss in the belt, the efficiency of each machine would come to, say, 93 per cent. The 240-kilowatt dynamos were tested in a similar manner, but the difficulties with respect to the belt were greater. There was not one to hand wide enough for the work, so the dynamo was driven by a 16in. double leather belt on the top of which rode a 12in. link belt. The following observations were made during the last half hour of a six-hour run with full load:—

E.M.F. Dynamo.	Excess.	Current.	Speed.	E.M.F. across magnets.	
				Dynamo.	Motor.
419	47·75	590	395	191	225
413	47·75	600	392	189	223
410	46·99	580	387	191	225
407	47·07	600	377	197	237

F. M. coils, motor (four parallel) 15·13 ohms.
F. M. coils, dynamo (four parallel) 14·31 ohms.

The coils were coupled four parallel for convenience of excitation; they run normally two parallel. From the above the following figures are calculated:—

Dynamo.		Motor.		Magnet Kwatts.		Speed.	Effiney.
Volts.	Kwts.	Volts.	Kwts.	Dyn.	Motor.		
419	247·2	466·75	275·3	2·55	3·34	395	87·8
413	247·8	460·75	276·4	2·49	3·28	392	87·7
410	237·8	457·0	265·0	2·55	3·34	387	87·63
407	244·2	454·07	272·4	2·71	3·71	377	87·46

Resistance of armature at end of run, 0·00916 ohm; cable connecting the two machines, 0·00044 ohm. These readings were taken on carefully tested instruments of Lord Kelvin's, the 400-volt reading being measured on an electrostatic voltmeter, and the difference of E.M.F. between motor and dynamo measured on a centi-ampere balance; by this means the efficiency could be arrived at very accurately. Without making any allowance for belt loss, which must have been heavy, the efficiency of one machine is thus 93·7 per cent. The power lost in the magnets and armature is very low, being only 1·06 per cent. in the former and 1·3 per cent. in the latter. These tests were taken under the superintendence of Dr. John Hopkinson, who certified the machines as 84·5 per cent. and 87·7 per cent. combined efficiency respectively. The tests on the Mather and Platt dynamos were arranged to the same specification, but were carried out without the use of belt gearing. They therefore showed a more nearly accurate and better result, giving a combined efficiency of 90·5 per cent., or an efficiency per machine equal to about 95·2 per cent. The

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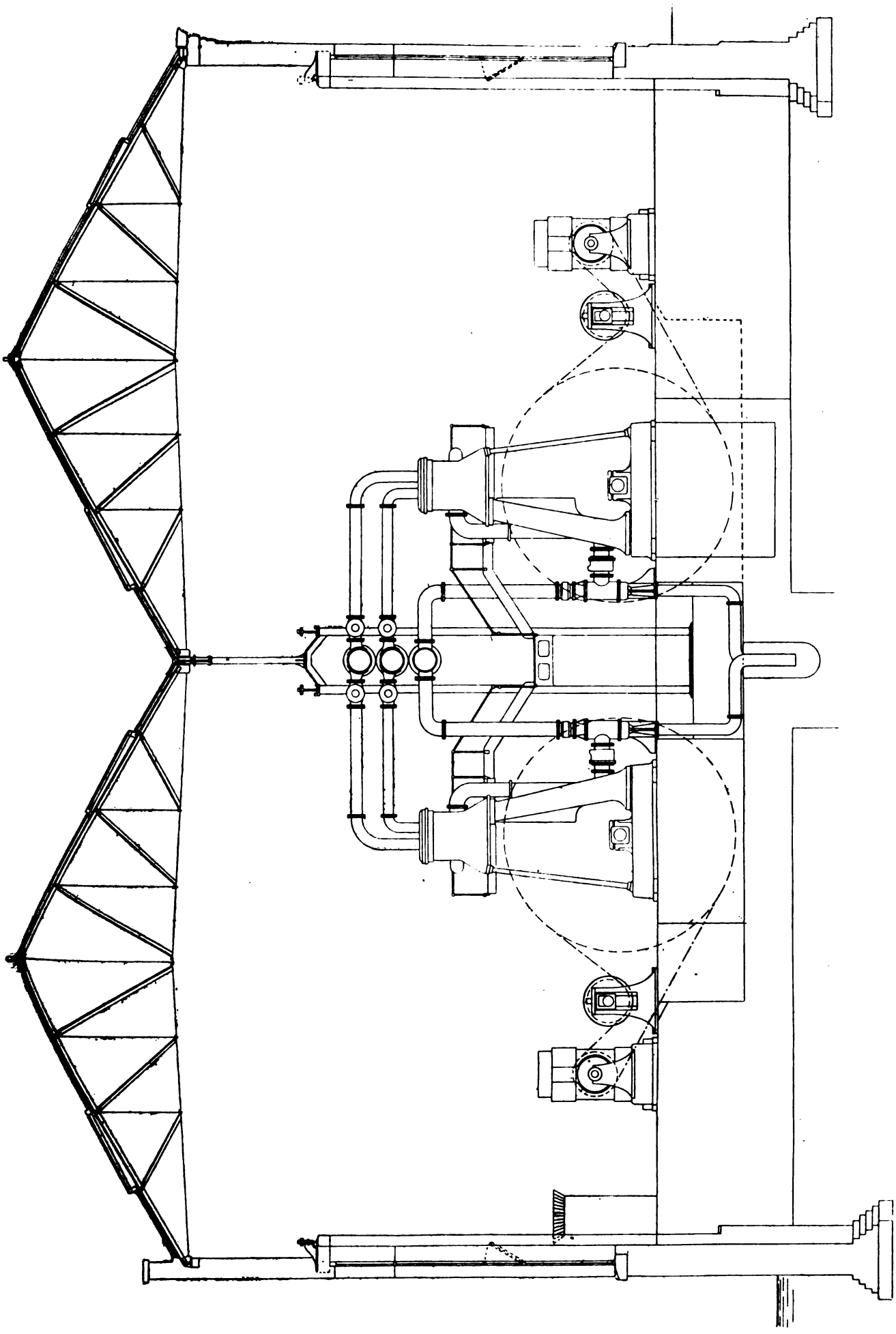

FIG. 3.—Manchester Municipal Power Station. Transverse Section of Engine and Dynamo House.
Scale 1in. = 9ft.

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stipulated combined efficiency in all these tests was 83 per cent., and a bonus of £30 per additional 1 per cent. was offered to the contractors.

The six small balancing dynamos are driven by six vertical tandem compound condensing engines, designed and erected by Messrs. R. Hornsby and Sons. These engines work by steam at 120lb. pressure, and are constructed to run at from 120 to 135 revolutions per minute. The high-pressure cylinder is 10½in. diameter, the low-pressure cylinder is 16in. diameter, and the stroke is 2ft., so that the piston speed varies from 480ft. to 540ft. per minute. This variation of speed is necessary on account of the variation of drop on the feeders being regulated entirely by regulation of the engine speed. The regulation is effected through the action of the governors on the cut-off valves, and not by throttle valves. There is a massive bed plate which carries the crankshaft, and on this is a vertical cast-iron frame at the back, and two wrought-iron columns at the front which support the low-pressure cylinder. At the top of the low-pressure cylinder, at a sufficient height to make it easy to get at the glands, the high-pressure cylinder is mounted. The slide of the low-pressure cylinder is on one side of the engine, whilst the high-pressure slides are on the other, the former being adjustable; and the latter consists of two slides, one having an automatic cut-off, which is regulated by the governor. The governor is of a massive description, of the Porter type, and is said to control the speed of the engine in a most efficient manner. The engines are supplied throughout with all the necessary lubricating arrangements so that they can be run continuously. The condenser is one of Ledward's automatic ejector condensers. The power is taken from the fly-wheel by link leather belting, an arrangement of jockey pulleys, enabling the engine and dynamo to be arranged on a very short "centre," thus econo misïng floor space. The large dynamos are driven by a similar arrangement of gearing, by vertical compound condensing Galloways' engines. Each of these engines has a high-pressure cylinder 17in. diameter and a low-pressure cylinder 34in. diameter, both pistons having 3ft. stroke. The cranks are set at right angles, which necessitates the use of a receiver for the steam in its passage from the first to the second cylinder. Both cylinders and the receiver are jacketed with live steam taken direct from the boilers. The speed of the engine varies with the load, and is regulated by Galloways' high-speed parabolic governor, so arranged that the speed of stability can be altered while running. The engines are intended to work at 120lb. steam pressure, and develop 400 I.H.P. at a piston speed of 500ft. per minute. Each engine is fitted with a Körting's ejector condenser, which is supplied with canal water by means of centrifugal pumps driven by separate engines.

The general arrangement of the engines and dynamos is shown in Fig. 3, in which a transverse vertical section of the station is given. This shows the jockey pulleys on the larger machines. The distance between centres in these machines is 11ft. 4in. between engine and jockey pulley, and 5ft. between jockey pulley and dynamo. The diameters of these pulleys are: Engine 16ft., jockey pulley 3ft., and dynamo 2ft. 3in. It might be supposed that the use of jockey pulleys with such large pulleys on these very short centres would cause a severe and wasteful thrust on the jockey pulleys; but, as a matter of fact, this does not appear to be the case. The jockey pulley is, of course, placed on the slack side of the belt, with the result that when the load is very large the belt sags below the jockey pulley surface, and gives a sufficient arc of contact on the driving pulleys without it.

The boilers are of the horizontal, cylindrical, twin-flue type, known as the Lancashire boiler, and are fitted in each internal flue with four Galloways cross tubes. They have been manufactured by Messrs. Galloways and Sons, and are intended to work at 125lb. steam pressure. Each boiler is 30ft. long and 8ft. diameter, and is provided with all necessary fittings, many of these in duplicate, and with a Vicars' mechanical stoker. The boiler arrangements and housing are shown in Fig. 5.

The boiler-house when complete will be provided with twelve of these boilers. Each boiler is automatically supplied with fuel, the coal being fed into the hoppers of the stokers from a traveller which runs along a platform over the end of the boiler-house. This platform terminates immediately over the side of the Manchester and Rochdale canal, the proximity of which affords great convenience for coaling and for the supply of condensing water. Water for the boilers is taken from the city supply, and is stored in capacious tanks, placed over a portion of the boiler-house, having a capacity of 200,000gals. The main steam pipes are of wrought steel, 18in. bore, welded, with strips double rivetted over the weld, and are duplicated throughout. They are supplied with steam from two separate stand-pipes on each boiler, and all the cocks and valves are in duplicate. The feed pipes, which are also in duplicate, are 5in. in bore, and supply the boilers with water which has been previously heated by one of Green's well-known furnace economisers. Air is supplied to the furnaces by natural draught produced by an octagonal chimney 212ft. high. The chimney foundation is 34ft. square, and the diameter of the chimney at the top is 11ft. 10in., about 1¾in. of water of draught being produced.

Having now described the general arrangements for generating power, it will be instructive to consider more particularly some of the details. The switchboard is of novel and ingenious design, and appears to be both well adapted to its present purpose and capable of ready extension without confusion

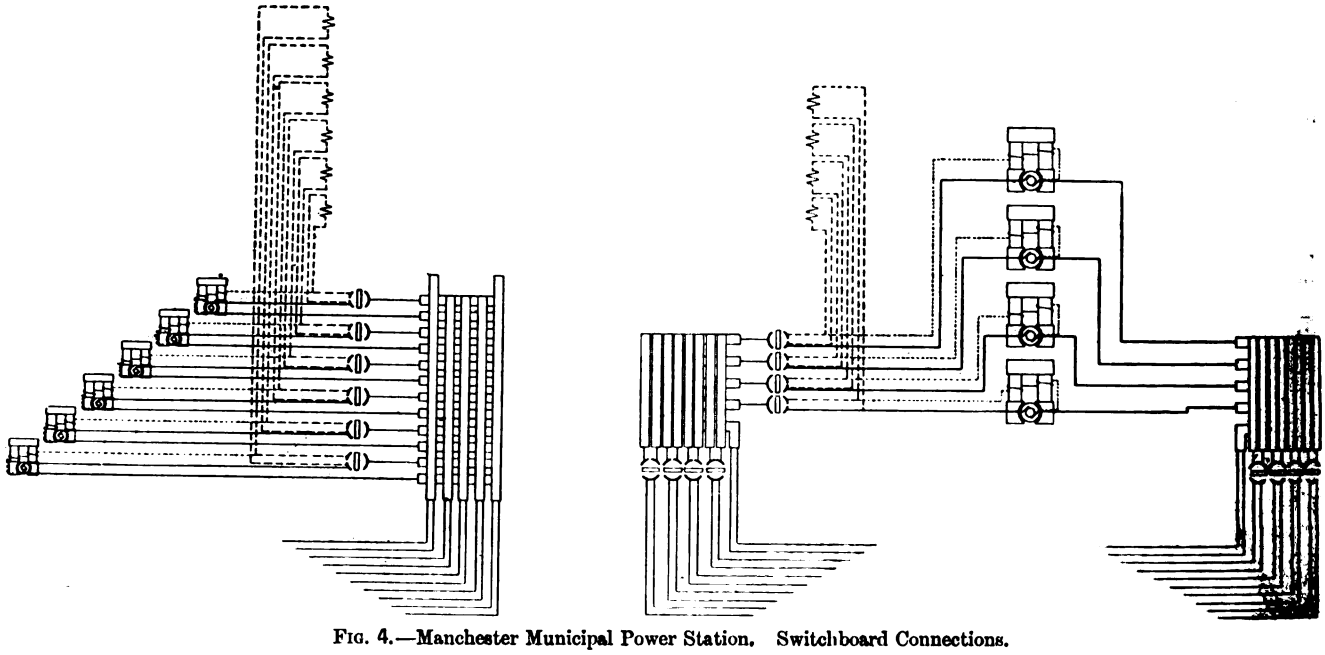

Fig. 4.—Manchester Municipal Power Station. Switchboard Connections.

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Mr. Crompton's resistance is a rectangular sheet of manganin, and the potential terminals are two screws inserted at a suitable distance apart in the median line. The screws are not soldered. I thought it would be of interest to unscrew them, then screw them up again, and remeasure the resistance. The results were :—

August 10th (morning)	0·00050328
August 10th (afternoon).....	0·00050322
August 10th (afternoon).....	0·00050327
Mean	0·00050326

a variation of about 1 part in 500.

I unscrewed them again, and after screwing them up once more remeasured, with the following results :—

August 11th (morning)	0·00050398
August 12th (morning)	0·00050403
Mean	0·00050401

which, compared with the first value, 0·00050222, gives a variation of, roughly, one part in 280.

The conclusion is that if an accuracy of one-tenth per cent. is desired the potential terminals ought not to be meddled with after the resistance has been determined.

In making these measurements my direct object has been to obtain an accurate and ready method of measuring these low resistances. But I think something more than this comes out of them.

It would be possible, in the light of our present experience, to construct a Lorenz apparatus considerably more accurate and easier to use than the one in my laboratory at Cardiff. Such an apparatus placed in the National Laboratory, of which we have heard a good deal at recent meetings of the British Association, might with advantage be kept in constant use, not only for the calibration of low resistances, but also as embodying in concrete form a proper ultimate standard of electrical resistance. We have not, in our electrical standard legislation, given full credit to the mechanical engineer for what he can do for us ; and I think that a coefficient of mutual induction, arranged as in the Lorenz method so as to be easily combined with a time, would afford a more satisfactory standard of resistance than any wire coil or coils, and one easier to use, for purposes of ultimate reference than any mercury column.

ON THE MAXIMUM EFFICIENCY OF ARC LAMPS WITH CONSTANT WATTS.*

BY PROF. H. S. CARHART.

It is of interest to determine, in connection with the proposal to define a 2,000-c.p. arc light in terms of the watts expended on it, whether the illumination is independent of the current as a variable. If a 2,000-c.p. lamp shall be defined as one requiring 450 watts for its maintenance, shall the current be 10 amperes and the potential difference of the arc 45 volts, or will a smaller current and a higher voltage give higher illumination ?

The present Paper can be considered as describing only a single step toward the solution of the problem, or a preliminary note relating to experiments conducted under one set of conditions. It seems quite clear that with any definite number of watts the candle-power will be a function of the current, the size and quality of the carbons, and perhaps also of the source of the current, whether from a constant potential circuit or from an open or a closed coil constant-current machine. The experiments conducted by three of my pupils, Messrs. Raymond, Hookway and Fisher, have been confined to the circuit of a constant-current dynamo with closed coil armature, and to soft plain carbons $\frac{7}{16}$ths of an inch in diameter, made by the Standard Carbon Company, of Cleveland.

The method employed was as follows :—With any constant current within limits a series of measurements of candle-power was made by changing the length of the arc and hence its potential difference. A curve was then plotted with candle-power and volts as co-ordinates. Fifteen such curves were drawn for currents ranging between 6·75 and 10·75 amperes. Then any number of watts were chosen, say 450, and this was divided in succession by the several currents used in obtaining data for the fifteen curves, or by so many of them as came within practical limits. With the potential differences obtained in this manner, and the corresponding candle-powers read off from the several curves, another curve was constructed, with candle-power and volts as co ordinates and with the watts constant. Such curves show a maximum point corresponding to the volts at which the lamp gives the greatest candle-power. The measurements were all made in the photometric room with a 32-c.p. incandescent lamp as a standard of comparison. The arc lamp was mounted so that the arc was at the extremity of a radius of half a metre, movable about an axis parallel to the photometer bar. The end of this axis carried a plate-glass mirror from which the light of the arc was reflected down along the bar to the photometer box. The arc or its image in the mirror was thus kept at a fixed distance from the incandescent lamp, and its position was always such that the light came from the arc at an elevation of 45deg. The absorption of the mirror was measured and found to be 8·7 per cent.

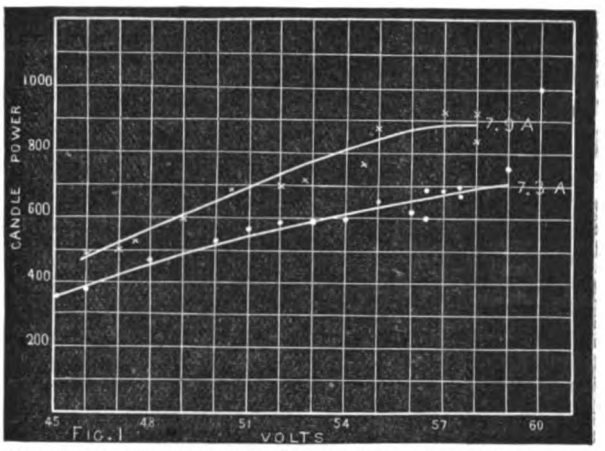

FIG. 1.—Candle-power and volts with 7·3 amps. and 7·3 amps.

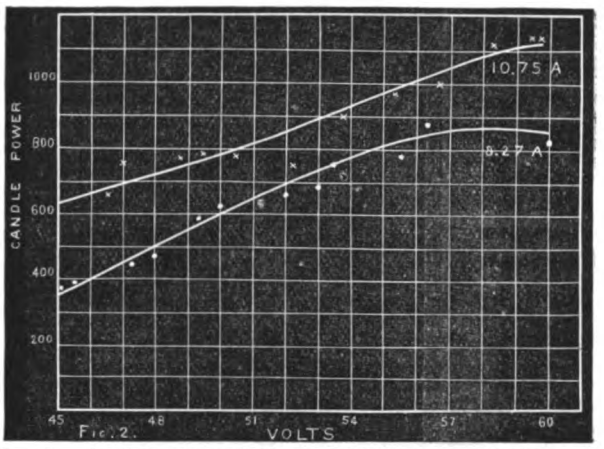

FIG. 2.—Candle-power and volts with 10·75 amps. and 8·27 amps.

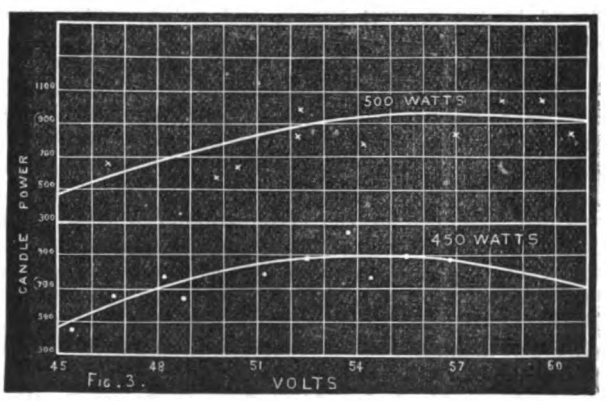

FIG. 3.—Candle-power and volts at 500 watts and 450 watts.

* A Paper read before the Electrical Congress, Chicago.

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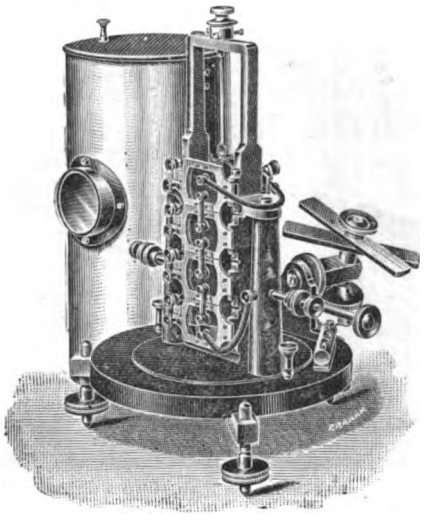
I have plotted only four of the fifteen curves composing the series. Fig. 1 contains two curves with currents of 7·3 and 7·9 amperes, and Fig. 2 two others at 8·27 and 10·75 amperes respectively. It will be seen that a maximum of only a little over 1,100 candles was obtained. Fig. 3 contains the two curves derived from all the data, and with constants of 450 and 500 watts respectively. Both show a pretty well defined maximum at about 54 and 55 volts respectively. Hence for a lamp of 450 watts the current should be about 8·4 amperes with the carbons described above. The candle-power was then 900. At 10 amperes and 45 volts this curve shows the surprising fact that candle-power was only 450. With 500 watts the current rises to about 9 amperes and the voltage to 55. I attach no great importance to these particular figures, but the series of experiments shows a very large variation of candle-power, current and potential difference varying inversely, their product or the watts remaining constant. It is proposed to extend the investigation to other carbons of different size and quality, and to currents of an open-coil machine; but enough has already been done to show that the definition of a 2,000-c.p. lamp as one on which 450 or 500 watts are expended is not so definitive or unobjectionable as might at first be supposed.

A SENSITIVE BALLISTIC GALVANOMETER.

Dr. Oliver Lodge described a new galvanometer for physiological purposes before Section A of the British Association at Nottingham. It was designed by himself and made by Messrs. Nalder Brothers. The nerve currents excited by stimuli



are exceedingly feeble, and, even with the so-called non-polarisable electrodes, the currents under investigation are frequently masked by other effects. Physiologists require an exceedingly sensitive ballistic galvanometer; but they appear generally to use needles which are far too heavy, in the endeavour to get a long period, and galvanometers which are too highly damped, and which manifestly cannot be so delicate as undamped galvanometers. The best form of galvanometer for their requirements is one which contains a very light needle built up of short pieces of highly magnetised steel wire and in which the coils are small, and are wound up as close as possible to the needles. The moving parts should be as small as possible to avoid damping. The instrument, which is shown in the accompanying illustration, has four such coils and four needles, forming an astatic system suspended by a quartz fibre in a very weak field. Compared with the usual galvanometers of the same resistance, its sensitiveness is at least twice as great. Prof. Boys has shown that excellent definition can be obtained from a small scrap of reflecting mirror; and Lord Rayleigh has shown that a pointer read by a microscope admits of just the same degree of delicacy as the mirror method. As biologists are accustomed to looking through microscopes, Dr. Lodge suggests that they might prefer to observe through a micrometer eyepiece a needle with a bee-sting as pointer, and thus avoid the weight of the mirror.

LAMP TESTS AT THE WORLD'S FAIR.

Prof. B. F. Thomas, Chairman of the Sub-Committee (4) of the Committee on Awards, has given out the following authoritative statement as regards the testing of incandescent lamps at the World's Fair. The lamps entered in the test are as follows:—

Edison lamp, 50 volts and 110 volts, and Thomson-Houston lamp, 50 and 110 volts, entered by the General Electric Company.

Novak lamp, 50 volts and 110 volts, by the Waring Electric Company.

Packard lamp, 50 volts and 110 volts, by the New York and Ohio Company.

Stopper lamp, 50 volts, by the Westinghouse Electric and Manufacturing Company.

The number of lamps of each make is limited to 40 of each voltage, or 80 of each make, except the "stopper" lamp of the Westinghouse Company, which enters simply as a 50-volt lamp.

The manner of testing that has been decided on by the Committee, and agreed to by the competitors, is as follows:—

Lamps entered for award shall be subjected to a test whose object shall be to determine the mean horizontal candle-power, the efficiency and life, and the blackening of the lamps entered at proper intervals during the time covered by the test.

Current Supply.—The Fort Wayne Electric Company has placed an engine and all dynamo machinery necessary at the disposal of the Committee; 110-volt lamps will be supplied with direct current and 50-volt lamps with alternating. Lamps will be placed on racks, on circuits of heavy copper rod, all lamps of a given voltage being on one circuit. Careful provision will be made to maintain voltage constant.

Standards.—The English sperm candle for candle-power. Electrical standards as agreed upon by the Sub-Committee on instruments.

Instruments.—For candle-power measurements, a Lummer-Brodhun photometer, length of bar, 250cms., Methven screen, using carburetted gas—gas to be filled with gasoline distilled between 35° and 50°C. The electrical instruments used will be Weston instruments, which will be tested at the beginning of the test, and at intervals during its progress by Sub-Committee (1) on instruments, &c. Recording voltmeters (if such can be obtained) will be placed on the life test circuits.

Scheme of Test.—The photometer being properly mounted, the Methven screen will be tested by comparison with standard candles. This test being satisfactorily completed, two or more 32-c.p. lamps, of proper voltage carefully selected with reference to uniformity of radiation in a given direction, will be tested at standard voltage. One of these lamps, so measured, and thereafter designated as working standard, will be placed on the photometer. Each lamp entered for test will then be compared with the working standard, both being carefully adjusted to standard potential. The mean horizontal intensity of each lamp will be obtained, preferably by spinning, when under comparison with the working standard, which latter will be maintained at about 16-c.p. The candle-power of each lamp in a marked position (azimuth) will also be determined at the same time, and its "position factor" derived. At the same time that the photometric work is done on each lamp careful reading of potential and current, or of potential and watts, will be taken. A storage battery will furnish current to all lamps when under photometric tests. At intervals (as small as convenient in the earlier days of the life test) each lamp will be removed from the test rack, placed on the photometer in its "marked position," and readings of candle-power, voltage and current (or watts) taken.

Results.—The data of the test will be completed and tabulated, and curves will be drawn so as to show the following points:—

(1) Mean horizontal candle-power, and percentage of initial candle-power, at each reading throughout the test.

(2) Efficiency (watts per candle-power) at each reading.

(3) Time of breaking of each lamp broken.

(4) Average cost of a candle-power hour of light produced by each make of lamp at intervals during its life, such cost to include cost of lamp and cost of energy required to operate it. Separate curves will be prepared for the average of each make, giving the above cost under varying conditions, varying from 15 to 50 cents for cost of lamp, and from 10 to 25 cents for cost of 1,000 watt-hours of energy.

Report.—A report upon the test, giving a full account of all points concerning the methods and instruments used, details of machinery and circuits, all original readings, &c., will be formally made to the proper official of the Exposition, with the recommendation that it be printed at the earliest possible date. The test will continue until October 1st, running 24 hours per day, and if at that time it seems desirable to continue the run, the committee will endeavour to secure such continuance. With the exception of "spinning," the above scheme is acceptable.

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THE CERTIFICATION OF THE HEFNER LAMP.*

The German Reichsanstalt has recently communicated to the papers some details, which are of importance to all those interested in the question of light standards, on the subject of the preparation and construction of the Hefner lamp, and the conditions which must be observed in order to ensure uniformity in its indications. As is well known to all who take an interest in this matter, it was in 1884 the Herr von Hefner-Alteneck first proposed a system of measuring the intensity of illumination by means of a unit, which he defined as follows :—"As unit of light shall be used that illuminating power which is possessed by a flame rising from a massive wick saturated with amyl acetate, and burning freely in pure, still air. The wick is to completely fill a german silver tube of 8mm. inner, and 8·3mm. outer diameter, and 25mm. clear length, and the flame shall be 40mm. high from the summit of the tube, measured not less than ten minutes after lighting the lamp." The intention of the Reichsanstalt to take up the question of the Hefner unit was greatly strengthened when, in 1890, the German Gas and Water Union, with the purpose of introducing the Hefner unit into gas work, applied to the Reichsanstalt to consider the question of issuing certificates for this form of lamp.

Preliminary experiments gave, on the whole, a result very favourable to the Hefner lamp. It was found that a very considerable degree of accuracy was unnecessary in the above dimensions, and the only important point appears to be the thickness of the sides of the wick tube, the illuminating power being diminished if the tube is too thick, while if it is too thin the flame does not burn steadily. A great degree of purity is necessary also in the amyl acetate, and simple means can be applied to detect excessive impurity ; and, in addition, the acetate is not affected by keeping. On the other hand, it is necessary to properly ventilate the lamp, as the pressure of carbondioxide has a very appreciable effect in diminishing the light ; there are also small variations due to meteorological conditions, but these are not large enough to affect practical work. Other small difficulties are due to unsteadiness in the flame, and the want of definite limits to measure the height by, but the great superiority of the Hefner lamp to other suggested units caused the Reichsanstalt to support strongly its adoption.

At the same time, the question of form was being discussed with the maker, and it was determined to adhere to the original specification. Every lamp to be certified should have a "flame-measurer" for determining the height, and an appliance for controlling the position of the flame-measurer above the upper side of the wick tube, and all lamps were to be to a standard pattern. As flame-measurer, the simplest forms were adopted, the Hefner-Alteneck eyepiece and the so-called "optical flame measurer" of Dr. Krüss. As far as the experiments at the Reichsanstalt go, two lamps, precisely similar in dimensions, burning in similar air, give within limits of observation precisely the same amount of light, that is to say, that a test of the Hefner lamp need only include proper measurements of its dimensions, but it has been considered as well also to measure the light photometrically, and to add the result to the certificate, in order to collect as much information as possible on the subject. It seems probable that even if the time has not arrived to make it a legal unit, the Hefner light will shortly displace the "standard candle" in Germany, as it has already for some years in the laboratories of the Reichsanstalt, and it will therefore be necessary to determine the ratio of the old and new units. The two old units most in vogue in Germany are the so-called English standard candle (flame 45mm. high) and the German Union Paraffin candle (flame 50mm.). The former gives a mean value of 1·41 Hefner light, and the latter 1·2.

The remainder of the report contains specimen certificates, instructions, tariff, and a description of the standard Hefner lamp.

IRON FOR TRANSFORMERS.†

BY PROF. J. A. EWING, F.R.S.

In selecting iron for use in the core of a transformer the first consideration is smallness of hysteresis losses ; high permeability is comparatively a secondary desideratum. These two good qualities do not necessarily go together ; the curve of the B-H cycle may have a relatively easy slope, and yet enclose a relatively small area. In actual tests the author has noticed that the order of merit in a set of samples is not always the same if permeability be made the criterion, as it is if smallness of hysteresis losses be the criterion.

Notwithstanding the obvious and well-recognised importance of small hysteresis losses in transformer iron, the metal that is actually used is often of a very poor quality in this respect. The author has been much struck by this in the course of a recent experimental inquiry in which ten or a dozen specimens of iron were examined, most of which were supplied either as transformer iron or as specially pure metal prepared for the purpose of the experiment. In only one case were the hysteresis losses as low as they had been found to be in some wire which the author tested in 1881, in the laboratory in the University of Tokyo, and in most cases the losses were much greater. In the Japanese tests which were made before the days of alternating-current engineering, when the word hysteresis was to be found nowhere but in the Greek dictionary, wires were taken at random from the stock which the laboratory chanced to furnish. Two of them were about equally good ; one of them was probably a piece of native iron, and the other was wire sent by an American manufacturer to an exhibition in Japan. Since then many observers have made tests, and, obtaining decidedly inferior results, have not unnaturally been led to express themselves in terms of politely veiled scepticism about the Japanese figures. It is therefore interesting to notice that one sample among those most recently tested by the author has given results which are substantially on a par with those given by the Japanese wires. Under strong magnetisation it is not quite so good, but when the magnetisation is moderate or weak there is practically no difference. The sample in question was thin sheet iron, used by a well-known English firm in the building of their transformers. But the corporation of the old figures, interesting as it is, only serves to emphasise the contrast between the good and the bad. Other iron, also used by eminent makers of transformers, and also, like the last, carefully annealed before testing, turned out so markedly inferior that the author does not care to indicate the sources of his specimens by any more particular description. And the case was even worse with some iron supplied as specially soft and pure.

The following figures may be given as representative :—They give the value of S H d I, or the hysteresis loss incurred in a complete cycle of magnetic reversal, for various values of the magnetic induction B which is reversed. Column 1 states the results of one of the old Japanese tests, column 2 refers to the good sheet iron mentioned above, and column 3 refers to another specimen of transformer metal, where, it will be seen, the losses are about half as great again as in the other. Column 4, where the losses are much greater still, relates to a test of some wire which was furnished as a specimen of particularly fine Swedish charcoal iron.

Table of Hysteresis Losses.

B.	Values of S H d I.			
	1.	2.	3.	4.
2,000	400	420	600	1,100
3,000	780	800	1,150	2,150
4,000	1,200	1,260	1.780	3,300
5,000	1,680	1,770	2,640	4,700
6,000	2,200	2,370	3,360	6,200
7,000	2,800	3,150	4,300	7,800
8,000	3,430	3,940	5,300	9,500
9,000	4,160	4,800	6,380	11,400
10,000	4,920	5,730	7,520	13,400
11,000	5,800	6,800	8,750	15,600
12,000	6,700	8,000	10,070	...

The figures given by Mr. C. P. Steinmetz in his Paper on "The Law of Hysteresis" (American Institute of Electrical Engineers, 1892) give additional evidence of the wide variation which this quality is liable to exhibit in different specimens of nominally soft iron.

Chemical analysis is apparently an imperfect guide in the estimation of magnetic quality, and to some extent this is intelligible enough. Puddled iron, for instance, liberally streaked with slag, may seem on analysis less pure than specimens of ingot metal which have much higher hysteresis losses. It is not improbable that much of the inferiority which most modern sheet and wire iron undoubtedly shows in this respect may be due to traces of foreign elements which have become chemically incorporated with the metal through the use of methods of manufacture which are ill adapted to yield a good product from the magnetic point of view, however successful they are in producing a mechanically good iron. Manganese, so essential to the strength and toughness of ingot iron, is well known to be deleterious magnetically. The makers of transformers complain that they are unable to get metal of the quality they want except by a kind of happy accident : that the conditions which bring about a good result are so imperfectly understood that they cannot be reproduced with any certainty. Much the same thing was true in the early days of mild steel, and incessant testing contributed to put matters on a surer footing. Magnetic testing is now easy for makers as well as users of iron, and it may be expected that specifications of magnetic quality, and particularly of hysteresis losses, will soon become commoner than they are. From being a mere laboratory affair, interesting only to the curious physicist, the subject has in a few years advanced to the front rank of practical questions, and affects wide commercial interests.

* Abstract from the *Zeitschrift für Instrumentenkunde*, No. 7, 1893.

† A Paper read before the Electrical Congress at Chicago.

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The form and general design of transformers has received all possible attention at the hands of engineers, but of the material which mainly determines their efficiency we apparently know very little. It is scarcely satisfactory to reflect that good makers are turning out machines which waste twice as much power as they need waste.

The author brings these remarks before the Congress in the hope that some suggestions may be made which will lead to a better understanding, as between electricians and iron makers, of the conditions which govern the production of magnetically soft iron.

SOME MEASUREMENTS OF THE TEMPERATURE VARIATION IN THE ELECTRICAL RESISTANCE OF A SAMPLE OF COPPER.*

BY A. E. KENNELLY AND REGINALD A. FESSENDEN.

In this Paper, which is of the greatest value in its bearing on laboratory and other work of high precision, the authors first discuss the results obtained by Drs. Matthiessen and Siemens in their classical determinations of the temperature coefficients of copper, and find that they are discordant. The work of other physicists in the same line is also referred to, and the final results of their own determination then resumed in the statement that "they indicate a linear relation between the resistance and temperature of the wire between the limits of 20°C. and 250°C. represented by the equation

$$R_t = R_0 (1 + 0{\cdot}00406\, t),$$

indicating a uniform temperature coefficient of 0·406 per cent. per degree Centigrade throughout that range, the maximum observed being 0·4097 per cent. and the minimum 0·399 per cent. at any point.

Concerning the conclusions that may be drawn, they feel only justified in saying that copper can be found in which a linear relationship holds between resistance and temperature between 20°C. and 250°C., and within the range of small observation errors. It is, of course, possible, they state, that in different samples of wire the temperature coefficient may increase or diminish with the temperature; in other words, the second differential coefficient of resistance, with respect to temperature, may perhaps, in some samples, be either positive or negative. It therefore seems desirable that fresh measurements should be made, and evidence collected to settle this point, and they submit the view that the best experimental means of measuring the temperature and insuring the coincidence between the measured temperature and that of the tested wire, is to enclose the latter in a bulb of an air thermometer in the manner employed in this investigation.

An account of the elaborate measurements is given in great detail in an appendix, not only to support the statements made concerning them, but also because the experimental arrangements of apparatus finally successful were the outcome of a series of experimental failures, and the details of construction may, therefore, be of service to those who desire to adopt the same method of measurement.

An interesting note accompanies the Paper, giving the result of some measurements made on the resistance of copper wires enclosed in exhausted glass tubes, and gradually raised to just visible red heat by gradually increasing the current through them. Assuming the linear temperature coefficient above determined throughout the entire range of temperature, the temperature corresponding to the lowest visible luminosity becomes 493°C. (921°F.). It was found that repeated tests with the same wire and the same observer will usually fall within 2°C. by resistance valuation. There was, however, a systematic variation between the observations when the observers were exchanged of about 3°C.

DISCUSSION.

Mr. PREECE stated that he would like, before the discussion was closed, to be allowed, as a representative from the other side of the water, to express not only their obligations, but their admiration for the manner in which Mr. Kennelly and his co-labourers are attacking this question. Personally he felt a very great interest in it, because it is a subject that he had himself attacked, and he only gave up the further study of the subject when he found that younger and abler men were taking it up on this side of the water. He wanted to point out to Mr. Kennelly that at Cambridge, where the question has been also carefully considered, the discrepancy between the curves of Matthiessen and Siemens, and also the discrepancy that is to be found in the text books and in papers generally as to the specific resistance of copper, is attributable to a difference of density. It has been found by reference to Matthiessen's original Papers that he used copper having a density of 9. At Cambridge they had been using copper which had a density of 8·946, and it was found that with the copper at this density the difference in the specific resistance formed a direct ratio between these two numbers. The numbers, he stated, happened, curiously enough, to be among his papers in a note that he took when Mr. Fitzpatrick read a Paper on the matter at one of the meetings of the British Association, he thought it was at Edinburgh, and the figure there given was for copper at 8·946 specific gravity and 18°C., 1·754; for copper at 8·9 density and the same temperature, 1·766. He remembered after that working that down with a coefficient, the coefficient then given for temperature, and he thought that if Mr. Kennelly would be kind enough to take that note and apply it to the formulas derived from his experiments with his revised coefficient, that we shall find that there will not be much discrepancy between the figure used in England and that used here. On the other hand, we shall be delighted to feel that we have a coefficient derived from the unique means that Mr. Kennelly has in his possession. And Mr. Preece assured him, as a representative of English electricians, that the result of his Paper will be accepted without the slightest hesitation.

* Abstract of Paper read before the Electrical Congress at Chicago.

AN ELECTRIC STREET RAILWAY CONDUIT TRIAL.

In a recent number of the *Electrical World* is an illustrated description of an interesting experimental conduit electric railway at Coney Island, one of the principal features of which is that the line is entirely insulated except when delivering current to a shoe projecting into the conduit from the car. Briefly stated, the system consists of a shoe projecting from the bottom of a car into a conduit, and a series of contact boxes connected with the line and placed at equal intervals along the sides of the interior of the conduit. Levers projecting from the boxes are moved when the shoe encounters them, which switches on the current from the line; the current then passes through the end of the lever by sliding contact on the metallic side of the shoe, and thence to the motor, whence it goes to the return line by the other side of the shoe in a similar manner. The line is completely insulated in the boxes within the boxes, except in those opposite the shoe, which are never more than three in number; as a consequence, any leakage can only occur during the brief time they are connected with the line, and this is provided for by careful insulation of the lever mechanism. A public experiment was made on Friday, September 15th, to show the quality of the insulation of the line under the most adverse circumstances. To this end about 100ft. of the conduit was filled with a mixture of mud and water, and the car was run back and forth, and stopped while readings of instruments were taken to determine if there was any leakage. The measurements showed that practically no part of the current was lost, and those in attendance pronounced the experiment as satisfactory and proving the claims made.

UNION OF THE ELECTRICAL ENGINEERS OF GERMANY.

The first annual meeting of the Union of the Electrical Engineers of Germany was held at Cologne from September 27th to 30th inclusive, when there was a large attendance of members. The evening of the first day of the proceedings was devoted to the reception of the visitors by the Cologne Electrotechnical Society, and on the following morning, by which time there had been many additional arrivals, a meeting was held, at which the President of the Union, Dr. Slaby, occupied the chair. After referring to the objects of the Union, he laid stress on the fact that it was important that the electrical trade should have freedom to develop, and for this the members should strive diligently. After some complimentary speeches had been made, the first annual report was read by Herr Sluzewski, from which it appeared that the membership of the Union had grown from 34 at the time of its formation last January, to 762. The meeting re-elected Dr. Slaby to the Presidency, while Herr Wilhelm von Siemens and Herr Rathenau were chosen as Vice-Presidents. A council of 30 was also appointed. It was agreed to hold next year's annual meeting at Leipzig, and it was also arranged that the members would take part in the Berlin Exhibition of 1896. Herr Pollak read a Paper on the subject of charging accumulators by alternating currents. He considered it often advisable to transform the alternating current transmitted from the generating station into a continuous current, using the latter for charging accumulators and driving direct-current motors. Little success had been met with in the past in this direction, but he had constructed a direct-current converter, of which the efficiency obtained averaged 98 per cent. The author believed that his system would be found of much value in connection with electrical tramway and railway working. The current could then be transmitted at high pressure, and then transformed down and converted into a continuous current. His apparatus could also be used for changing continuous into alternating currents. The system was afterwards shown at work. Herr Ross next read a Paper on the Thomson electric welding system, of which a practical demonstration was subsequently given. The proceedings of the Electrical Congress at Chicago were dealt with by Dr. Budde, who drew special attention to the official fixing of the units.

On September 29th Herr Ross gave a description of the Lagrange and Hoho electrical method of raising metals to a white heat and

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welding heat, and it was pointed out that by this process even platinum and iridium could be dealt with. The process was also shown in operation at Herr Gottfried Hagen's accumulator works at Kalk. Dr. Kallmann next read a Paper on a Measurement System for Central Stations. Herr Voigt proposed that a committee should be formed to go into the question of arranging a standard for contacts and screws employed in switches, safety apparatus, &c. This proposal was agreed to, and the committee will report next year. Dr. C. Heim spoke on the subject of a portable apparatus for testing the insulation resistance of non-conducting material covering electric conductors and used for their supports. The apparatus is carried in a box, and consists of a delicate galvanometer with two shunts to diminish the sensitiveness by from a tenth to a hundredth, and having a resistance gauge of 10,000 ohms. There is also a dry cell battery, and the current from this can be regulated. Dr. Heim stated that this appliance enabled him to determine insulation resistances from 30,000,000 ohms down to 1,000 ohms. The gathering subsequently devoted itself to visits to works and various festivities, bringing the first annual meeting of the Union to a successful conclusion.

ELECTRIC SUPPLY IN CENTRAL QUEENSLAND.

The Rockhampton Gas and Coke Company's Central Electrical Supply Station was put down under Act of Parliament, under condition that electricity for public and private purposes must be supplied by them within five years. The plant, which was started in September, 1892, consists of two 120 H.P. Root's boilers, by Conrad, Knap and Co., Lincoln; a 100 I.H.P. horizontal engine, by Davey, Paxman and Co.; a 6½in. by 6in. Westinghouse engine; a 280-ampere 110-volt Hookham patent dynamo, with constant lead brush gear, hand regulated by resistances in the field circuit; and an A7 Mordey Victoria alternator. The whole plant is thus capable at present of supplying 2,000 8-c.p. lamps, of which 914 are already in use and 1,700 on order. The Fitzroy Bridge is lighted by alternate-current arcs, and the cathedral by 8 arcs and 20 incandescents. The whole of the mains are laid underground on the Callender system, and the current is charged by Hookham's meter, or by contract, as the case demands. The supply is from 4 p.m. to 7 a.m., and is maintained well. The Company are also contractors for isolated plants, their largest at the present time being the re-establishment of the electric light plant at the Mount Morgan Gold Mining Company's works, Mount Morgan. The whole of the old Weston system has been thrown out, having broken down entirely. Their new plant consists of a 60-light and a 25-light 10-ampere Kapp dynamo with Brockie-Pell arc lamps in series, and a Crompton 100-light dynamo for incandescent lamps. The circuits are over eight miles in length, overhead on poles, and Johnson and Phillips' patent fluid insulators are used. The engine is a 20in. coupled high-pressure Fowler (of Leeds) and two Paxman Lancashire boilers. Over 50 arcs and 30 series Bernstein lamps are in use on the high-tension circuits, and 85 incandescence of 16 c.p. on the Crompton. These two plants are the largest in Queensland, and have been planned and erected under the superintendence of Mr. A. E. Neal.

ELECTRIC LIGHTING AT THE GARDENING AND FORESTRY EXHIBITION.

We have received from Mr. G. C. Fricker the following particulars of the electric light plant for the above Exhibition and grounds, including Capt. Boyton's Water Show and the model Eddystone lighthouse. It comprises almost every practical system of lighting by electricity, viz., high-pressure series arc lighting, low-pressure parallel arc lighting, alternate-current arc lighting with transformers, high-pressure alternate-current incandescent lighting with transformers, and direct-current electric motors and alternate-current electric motors, besides the special arrangements required for the automatic luminous fountain and the ornamental coloured lights in the trees on the lawn of the Welcome Club.

The steam generating plant in the main engine-room consists of four steel locomotive boilers by Messrs. Davey, Paxman and Co., each capable of evaporating about 300 gallons of water per hour, and working at a pressure of 120lb. per sq. in.; one compound horizontal fixed engine, capable of working up to 210 I.H.P.; one compound horizontal fixed engine, capable of working up to 120 I.H.P.; and one coupled compound engine of the girder type, capable of working up to 120 I.H.P.

These latter, which are also by Messrs. Davey, Paxman and Co., are arranged to drive respectively on to three independent countershafts working in line with couplings ready for connection in event of any one engine being stopped. From this line of countershafting the dynamos are driven by means of belts. The dynamos are supplied by the Brush Electrical Engineering Company, and consist of eight arc light machines each capable of running 35 10-ampere lamps in series, two of which are running idle as spare machines in case of breakdown; two low-pressure direct-current Victoria dynamos used for the large projector arc lamps in the arena section; and one 100-kilowatt Mordey alternator, and one 37-kilowatt Mordey alternator. The larger of the two alternators, working at 2,000 volts pressure, is employed to maintain all the incandescents throughout the building and grounds, numbering 1,000 lamps, also the arc lamp for the luminous fountain, these all being worked in groups from "small transformer sub-stations." The 37-kilowatt alternator supplies the current for the lighthouse only, also transformed down from 2,000 volts. In addition to the above plant a complete set of gas engine, dynamo, and accumulators is in operation to maintain a continuous light for an experiment in plant culture under electric light, daylight being completely excluded. The accumulators here maintain the light during the night.

The 210 arc lamps throughout the building and grounds are of the Brockie-Pell type, supplied by Messrs. Johnson and Phillips. An interesting feature of the outdoor lighting is a small illuminated fountain in the Western Gardens. This has been specially designed by Mr. Fricker, and is a new departure in colour-changing fountains, being perfectly automatic in action and having worked successfully throughout. The light from a powerful arc is thrown horizontally from some 15 yards distance in parallel-coloured beams on to a mirror at 45deg., from which it is reflected vertically through a glass plate under the jet. There are five distinct colours, which succeed each other at an interval of one minute by means of a simple relay and electromagnetic gear. The lighthouse in the central gardens carries one of the most powerful arcs which has ever been used. The current supplied is 250 amperes, and the light is refracted by a set of revolving lenses into 12 separate beams, which, as they slowly sweep the horizon, can be seen for many miles around London. The lighting of Capt. Boyton's Water Show constitutes a large section. There are on the roof around the arena 10 projector lamps, each of about 10,000c.p. to 15,000 c.p., and three search lamps of some 20,000 c.p. to 30,000 c.p. each. In addition to these there are 20 arc lamps of 2,000 c.p., and about 100 incandescent lamps scattered over the ground. The effective result of the whole lighting speaks well for the general scheme, and, at the same time, the fact that there has not been a single failure or hitch of any kind throughout the whole plant in the exhibition bears testimony to the thorough character of the work and the excellence of the machinery. Much must be said for the care and attention which such a successful result necessarily entails, and in this connection Mr. Fricker wishes particularly to acknowledge the valuable co-operation of his foreman Mr. D. F. Adamson, and his assistant Mr. F. Miller, who have had charge of the job. We understand that, as a mark of the appreciation in which Mr. Fricker's services have been held, a special honorary medal has been awarded to him for the electric lighting of the Exhibition.

CORRESPONDENCE.

ON THE USE OR ABUSE OF SECTIONS A & G.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It has sometimes struck me from the tone of letters and Editorials that there may be some dissatisfaction with the mode in which Sectional work at the British Association is usually conducted. For myself I have not felt any such dissatisfaction, because I have thought that for serious publication and recording of new results and other formal purposes societies in London had a preponderating advantage. My idea was that the British Association was best adapted to a conversational account of what was going on, to a friendly and mutually helpful impromptu discussion among the workers, and that serious set Papers to be circulated beforehand and elaborately discussed were out of place. New results are indeed often brought before a Section, but they are usually brought in an informal and preliminary sort of way, sufficient to awaken interest in, and secure attention to, the record when ultimately published, but not constituting the official record itself. So many societies exist for the formal reading of Papers that it would seem to me a pity for Section A and Section G to merely add two to their number. I am only expressing my individual opinion, which may very

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well be wrong, and if you thought fit to open your paper to a discussion of the matter, perhaps whatever feeling of dissatisfaction may exist would display itself in a manner instructive to future organising committees.—Yours, &c.,

OLIVER J. LODGE.

CHICAGO CONGRESS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is only due to Mr. Preece that I should point out an error that has slipped into the last sentence of my article on the Chicago Congress, where I allude to a reception given to members of the Congress "by the British Commission." To be completely accurate it should run, "given at the house of the British Commission by the President of the Institution of Electrical Engineers." The house was indeed lent for the occasion by the British Commission, of which body Mr. Preece is also an active member, but the inception, arrangements, and expense of the reception fell upon Mr. Preece alone.—Yours, &c.,

SILVANUS P. THOMPSON.

"NEW LAMPS FOR OLD."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to Prof. Ayrton's article in your last issue on the economy of over-running glow lamps, it may be useful to look at the subject from another point of view.

The pith of the matter seems to be in the fact that by putting a few volts extra through the lamps an over proportionate increase of light is obtained, and though the time factor is diminished yet, on the whole, the sum of the candle-hours is increased.

This is the theory. Can it be made use of in practice? Prof. Ayrton says "Yes," inasmuch as he recommends the use of 97-volt lamps on 100-volt circuits, but the real question seems to me to centre upon the necessity for having the extra brilliancy of the lamps and the willingness to pay for a greater number of new lamps to replace the burnt out ones.

In electric installation work, the usual plan being to pay so much for each lamp installed, it is a pretty sure thing that if the contractor has anything of a free hand there will be no lack of light; in most cases the full effects are too dazzling for comfort. This being so, it does not seem conducive to economy to make things so much more brilliant when it is at the expense of the lamp's life, and this argument also applies to cases where there is just a sufficiency of light. If, however, it is possible that a house has been sparsely supplied with lamps, and its occupants want more light, over-running would be probably cheaper than increasing the fittings.

So, then, it would seem that for most already fitted houses over-running is needless and expensive. It may be, however, that future generations of electrically installed houses will reap the benefit of Prof. Ayrton's experiments. Fewer lamps will be required for the same light, thus saving in fittings as well as in the meter, but, as the concluding paragraph of your current leader seems to imply, the inconvenience of a more frequent extinction of lights and the nuisance of replacement have to be considered.

There are other points to this question of over-running, but perhaps the subject is not of sufficient importance to warrant a further intrusion upon your valuable space.—Yours, &c.,

J. H. C. BROOKING.

October 3, 1893.

ALTERNATE-CURRENT MOTOR TESTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In an Editorial note, page 571, September 29, 1893, referring to the article of our engineer, Herr Emil Kolben, you mention a test made by Col. Turrettini at the Geneva Central Station. The alternate-current motor of 10 H.P., which took a starting current equivalent to 37 H.P., is, however, not of Oerlikon origin, as might be suggested by the Editorial paragraph, but has been made by Brown, Boveri and Co., of Baden. The tests with Oerlikon motors did not take place until a few days ago. There was one 9 H.P. and one 12 H.P. alternate-current motor of not quite the same design. Both took a starting current equivalent to 15 H.P., that is to say, with regard to the out-put of the motors, about 2½ and 3 times less starting current respectively than the motor made by Brown, Boveri and Co.

But for the interest attached to the alternate-current motor question, I would rather not have sent you these lines, which might look as if suggested by competition. I would only state, that a motor of 12 H.P. effective, taking a current from the mains equivalent to 15 H.P., is by no means useless, and justifies further additions to the theoretical and descriptive literature on alternate-current motors.—Yours, &c.,

Zurich, September 30, 1893. EMIL HUBER.

[Neither the observation that some so-called self-starting motors are almost useless on account of the excessive starting current, nor the allusion to the 10 H.P. motor at Geneva, referred to the Oerlikon Company. We had no confirmation of the test from the makers of the motor, and therefore omitted their names.—Ed. *E.*]

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

"DRUM ARMATURES AND COMMUTATORS."—This book, which is written by Mr. F. Marten Weymouth, and is the latest addition to *The Electrician* Series, is now ready, and will be sent direct by the publisher on receipt of the published price, 7s. 6d., or it may be obtained from any bookseller. A prospectus will be forwarded on application.

TENDERS INVITED.—The Northern Co-operative Company invite tenders for the supply of an electric lighting plant for their central premises at Aberdeen. Specifications may be obtained from the Secretary, Mr. John Ferries, to whom tenders must be sent by the 25th inst. Further particulars appear in our advertisement columns.

——— Mr. N. J. Psiachi, of Cairo, invites tenders for the electric lighting of some buildings in that city, with about 1,500 glow lamps of 10 c.p., and 12 arc lamps of 350 c.p.

——— The Electric Lighting Committee of the Lancaster Corporation invite tenders for the brickwork, &c., required in the fixing of two boilers, and a set of economisers at their electricity works. Tenders are to be in by Wednesday next, the 11th inst.

——— The St. Pancras Vestry are prepared to receive tenders for the building of the chimney shaft at the East St. Pancras Central Station, King's-road, N.W. Tenders are to be in by October 16th.

TENDERS RECEIVED.—The Technical Instruction and Public Library Committee of the York City Council recommend the lighting of the Institute building by electricity, and also suggest that the tender of Messrs. Benson and Co., of London, for wiring the building for the sum of £314 be accepted.

TENDERS ACCEPTED.—The Gas Committee of the Aberdeen Town Council have accepted the tender of Messrs. Crompton and Co. (Limited) for the supply of copper connectors for the electric lighting plant.

APPOINTMENTS VACANT.—The School Board for London want, for the training-ship "Shaftesbury," an electrical engineer and a stoker mechanic, to take charge of the electric lighting apparatus. Applications to be sent to the Clerk of the Managers, School Board Offices, Victoria Embankment, W.C., by the 13th inst. Particulars will be found in our advertisement columns.

FOR SALE.—Messrs. T. F. Ashe and Nephew, of Atherton-street, Liverpool, announce in our advertisement columns that they have for sale 30 E.P.S. L type accumulators with accessories complete; also slate switchboard, &c., for use with same.

PERSONAL.—Mr. Lee has been appointed engineer to the Southampton Electric Light and Power Company (Limited), in place of Mr. K. A. Scott Moncrieff, who has left to join Messrs. Kilburn and Co., the Calcutta agents for Crompton and Co. (Limited).——Mr. C. J. Robertson has severed his partnership with, and his duties as Technical Director to, the "Watt" Glow-lamp Factory of Vienna, and has now joined the Incandescent Electric Lamp Company (Limited), of Brook-Green Works, Hammersmith, W., as their engineer and managing director.

REMOVAL.—The Secretary of the Crocker-Wheeler Electric Company announces that "Ampere is now their ohm," which, being interpreted, is that the town of Ampere (N.J.) is now their home and abiding-place. This is current news.

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MR. N. F. NALDER.—This gentleman informs us that he has commenced business at 8 and 10, Charing Cross-road, W.C., as a manufacturer and repairer of all kinds of electrical instruments, &c.

BANKRUPTCY.—A receiving order has been made against William Andrews, lately trading at 118, Hunger Hill-road, Nottingham, as an electrician.

ELECTRICAL TRADES UNION.—A new branch of this Union is to be opened on Monday, October 16th, at the "Swan" Tavern, Caledonian-road, N., at 8 p.m.

THE SILVERTOWN CABLE COMPANY.—We have recently received copies of the revised catalogues and price lists of the cables and other electrical goods manufactured by the India-Rubber, Gutta Percha, and Telegraph Works Company, at Silvertown. From a comparison of these with the previous issue we find that the classification of cables is not appreciably altered; but we are glad to notice that the prices of almost all the classes of cable goods rule substantially lower than before. The excellent character of the Silvertown cables is well known in the trade, and is above criticism. This firm also supplies dynamos, batteries, and electrical fittings.

STEAM-SAVING APPLIANCES.—The steam-saving appliances, described in a pamphlet we have received from Messrs. McDougall and Co., comprise a steam trap, which ejects automatically, and without loss of steam, a steam separator or dryer, which returns the water in the steam to the boiler, anti-priming apparatus, mechanical stokers, and sight-feed lubricators. It will be seen that Messrs. McDougall and Co. have attacked the important problem of steam and fuel economy at almost every possible point.

INCANDESCENT LAMPS.—With reference to the Trade Note in our last week's issue respecting the purchase of the Brook Green Works, Hammersmith, we learn that these works have been started by the Incandescent Electric Lamp Company (Limited) to manufacture Mr. C. Robertson's incandescent lamp. The General Electric Company (Limited) are largely interested in the new Company, and have undertaken the sale of the lamps.

MESSRS. DRAKE AND GORHAM.—This firm have obtained the contract for the lighting of Messrs. Agnew and Sons' picture gallery at Manchester, where about 160 lights will be installed. Messrs. Drake and Gorham's Manchester staff are, we understand, also busy on several other installations in the district.

ELECTRIC PUMPING PLANTS.—Messrs. Ernest Scott and Mountain (Limited), of Newcastle-on-Tyne, have contracted with the Lothian Coal Company, Newbattle Collieries, Dalkeith, for the supply of two electric pumping plants. The plant will consist of two compound horizontal condensing engines, each engine to be capable of giving 120 effective horse-power, which will drive two "Tyne" dynamos, each capable of giving an output of 60,000 watts. The pumps are placed at the bottom of the pit, each set being capable of delivering 200 gallons of water per minute against a head of 600ft.; they are driven by "Tyne" electric motors.

BEDFORD.—In June last the Town Council met to consider the tenders which had been received in reply to an advertisement respecting the carrying out of the powers granted under the Corporation's Provisional Order. Mr. F. H. Medhurst, of Cambridge, made two alternative propositions—one that the Provisional Order be transferred to himself, and in the other he offered to supply a complete installation for the sum of £24,000; Messrs. C. A. Parsons and Co. offered to lay down plant at a cost of £12,000, exclusive of buildings; and a third offer was from the Bedford Electric Light Company (Limited). The Town Council were recommended by the Electrical Sub-Committee to accept the latter. The matter was, however, remitted to the Sub-Committee for further consideration, and their report was presented to a special meeting of the Town Council held on Thursday last week. A long and somewhat acrimonious discussion ensued, with the result that a resolution to hand over the Corporation's powers to the Company was carried by a small majority.

BLACKPOOL.—The Town Council, it will be seen by an advertisement in another column, have decided to hold a grand electrical *fête* on the occasion of the inauguration of the Corporation electricity works on the 18th inst., when the new arc lamps along the promenade will be lit for the first time; and it is proposed also to festoon the whole length with incandescent lamps. The tower will be outlined from top to bottom with incandescent lamps, surmounted by a group of arc lamps and a powerful search-light. There is also to be a grand illuminated cyclists' parade. Lord Kelvin is to speak at the subsequent banquet.

CHICHESTER.—The Lighting Committee of the Town Council reported at the last meeting of that body that they had appointed a sub-committee to interview the Gas Company's representative, and that they had under consideration the question of introducing the electric light, but they had not yet arrived at any decision.

CHELSEA.—The Chelsea Board of Guardians have decided, in reply to a letter from the Chelsea Electric Supply Company, not to take any action in the matter of electric lighting at present.——Upon a letter being read from the London Electric Supply Corporation at the meeting of the Vestry on Tuesday, as to their supplying the Vestry Hall with electric light, it was resolved to refer the matter to the Hall and Electric Lighting Committees in order that the question could be thoroughly gone into.

DEWSBURY.—The Electric Lighting Committee of the Board of Guardians, with reference to the tenders for lighting the workhouse, &c., recommended the Board to formulate a specification based upon the several tenders received, which should also be made to provide for the lighting of the cottage homes, and to contain a clause to guarantee the proper and effective lighting of the workhouse, &c., for a reasonable period thereafter, and that the tenderers submit tenders in accordance with such specification. The Chairman of the Committee said they had gone very carefully into the matter, and they had come to the conclusion that the cost of lighting the premises by electricity would be less than by gas. After a short discussion, the Board adopted the recommendation of the Committee, and likewise decided to apply for power to borrow £2,100 for electric lighting purposes.

DOVER.—The Brush Electrical Engineering Company have laid before the Electric Lighting Committee of the Corporation the proposed Memorandum and Articles of Association and prospectus of the Dover Electric Supply Company (Limited), and the committee have recommended the Council to approve of the same. We understand that the Tennis Club Ground in Park-street has been selected as a site for the central station in the event of the Company being successfully floated.

DUNOON.—The Police Commission have agreed to a recommendation of their Lighting Committee that they refuse consent to the Caledonian Electric Supply Company's proposal to apply for a Provisional Order, and that the question of introducing the electric light into the burgh be remitted to the committee for consideration.

GREAT MISSENDEN.—A meeting was recently held in the schoolroom to further consider whether the Lighting Act should be adopted in the district comprising the village only, and also to consider a proposition of the British Volt Electric Glow Lamp Company to provide all the plant and fittings at their own cost, and also to provide 13 electric lights each night from September to March, for all hours from one hour after sunset to 10:15 p m., on condition that the charge to the village shall not exceed £15 per year. There was a large attendance, and it was resolved to accept the proposition of the Company.

GRIMSBY.—The Public Lighting Committee of the Corporation had the question of electric light again under consideration at their meeting on Monday, when the surveyor said that he had not yet received replies from all the local authorities with whom he had communicated as to the cost, &c. It was decided to appoint a sub-committee with a view to obtaining a Provisional Order.

LAMBETH.—The Board of Guardians at their meeting on Wednesday week took into further consideration the report of Mr. W. H. Preece upon the electric lighting of the workhouse and infirmary, and finally resolved to take no further steps regarding the scheme.

LEAMINGTON.—It has been decided to light the parish church by electricity at an estimated cost of £250.

LONDON COUNTY COUNCIL.—At the meeting on Tuesday the Finance Committee reported the result of the negotiations with the Treasury on the subject of electric lighting loans, consent having been given to the inclusion in such loans, spread over not more than 50 years, of the whole initial cost of the undertakings. This was subject to the general understanding that the Council would be professionally advised on each case, and that where any considerable proportion of the amount of a loan was for "short-lived purposes" the fact would be considered in fixing the period of the loan. On the recommendation of the same committee a loan was granted to the Vestry of St. Pancras of £8,000 for electric lighting purposes. It was also agreed: "That it be referred to the Highways Committee to consider how far the proposed agreement about to be made between the National Telephone Company and the postal authorities will affect the Council's position in regard to the telephone service in London, with power to confer with the Postmaster-General."

LYNTON.—The Local Board have had an offer from Mr. Benn to sell the electric light works to the Board. The Board were already paying £143 for lighting, and if they would add another £50 to that amount he said he would hand over the works and undertake it. He estimated that the working expenses amounted to about £250, and the revenue from private consumers came to £400. After the lapse of 42 years the undertaking would become the absolute property of the Board. A special meeting of the Board was to be held to consider the offer.

NORWICH.—The Secretary of the Norwich Electricity Company (Limited) notifies the public that the consumers of electricity who have been supplied with current up to October 1st by Messrs.

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Laurence, Scott and Co. (Limited) will in future be supplied by his Company.

PETERBOROUGH.—The Town Council on Thursday last week decided to apply to the Board of Trade for a Provisional Order enabling them to supply electricity within the borough. An abstract of the Borough Engineer's report on the subject appeared in last week's *Electrician*.

PORTISHEAD.—In reply to advertisement requesting tenders to be sent in for lighting the public lamps, the Local Board received three tenders, one for an installation of an electric lighting plant, and the others for lighting the district by oil and by gas. The electric lighting tender suggested the purchase of plant to the amount of £12,450, the tender for lighting by oil worked out at £2. 4s. 6d. per lamp, while the local gas company offered to light the lamps at £2. 2s. each. After a short discussion, the tender of the gas company was accepted.

SHEFFIELD.—The Sheffield Electric Light and Power Company obtained Parliamentary powers in June, 1892, for the electric lighting of the city, and they will soon be in a position to generate electricity sufficient for the supply of 150,000 lamps. Applications for current have been numerous enough of late to confirm the Company in their opinion that their action will be appreciated. The main station is in process of construction at the bottom of Commercial-street, and eight converting stations or transforming chambers have been erected in various parts of the city, the power for the whole of which is to be derived from the central station. Current will be supplied from the central station at a pressure of 2,000 volts to the various transforming stations. The high-pressure system has been adopted in Sheffield on account of the large area to be dealt with—an area which includes every part of the city. As soon as the underground work in connection with the compulsory area is complete the Company will proceed to extend the wire to the Broomhill and Ranmoor districts, where a large demand for the current is anticipated. The work connected with the reconstruction of the central station is being vigorously proceeded with. Five Babcock and Wilcox boilers have already been put down, and two additional engines and alternators, manufactured by the Brush Electrical Engineering Company, are being erected. There are a number of Mordey-Victoria alternators working at a pressure of 2,000 volts: these are rope-driven from high-speed vertical engines. The supply of electricity to consumers is made at present from overhead wires, but the wires which will supply the city under the new scheme will pass underground. The construction of the last transformer chamber is now complete, and nearly all the underground work is finished. The mains have been laid on the Callender system.

SUNDERLAND.—The Highways Committee of the Sunderland Corporation had under consideration at their last meeting the report of Prof. Kennedy on the scheme of electric lighting for some of the principal streets. The committee decided to obtain further copies of the ten sets of plans, and to have complete specifications made out in accordance with Prof. Kennedy's suggestions, and also to advertise for tenders from electrical engineers for supplying and fixing the plant. It is proposed to utilise Dunning-street Hospital as a central station.

TAUNTON.—A special meeting of the Town Council was held on Monday, when the borough seal was affixed to the contract with the Taunton Electric Lighting Company (Limited) for the purchase of their works and plant. It was stated that Dr. Fleming had been interviewed as to the carrying on of the work, and he would report in due course.

WEST HAM.—The Town Council have decided to defer for six months the question of the electric lighting of the borough.

WOKING.—We understand that the great demand for the electric light at Woking has necessitated extensive additions to the plant of the Woking Electric Supply Company, extra machinery having been added, which will enable the Company to double their production.

BOOKS RECEIVED.

"Electric Lighting and Power Distribution." Part III. By W. Perren Maycock. Price 2s. 6d. (London: Whittaker and Co., Paternoster-square.)

"British Locomotives." By C. J. Bowen Cooke. (London: Whittaker and Co., Paternoster-square.)

"The Principles of Fitting." By "A Foreman Pattern-maker." (London: Whittaker and Co., Paternoster-square.)

"A Manual of Telephony." By W. H. Preece and A. J. Stubbs. (London: Whittaker and Co., Paternoster-square.)

"The Calendar of the Glasgow and West of Scotland Technical College." (Glasgow: R. Anderson. 1893.)

"The Calendar of the Durham College of Science," (London: Whittaker and Co.)

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

September 15, 1893.

17,341. G. KAPP. Manchester. Improvements in alternate-current dynamos.

17,348. H. W. BOWDEN and W. BOBY. London. Improvements in electrical transformer street surface boxes.

17,352. T. W. SCHMIDT. Bradford. Improvements in electrically controlled arc lamps.

17,372. H. LÜDEKE, E. L. A. LÜDEKE, A. J. THORMAN, E. DE BUNSEN, and E. M. HORE. London. Improvements in magneto-electric motors.

September 16, 1893.

17,445. W. H. SCOTT. Norwich. Improvements in pipe conduits for electric mains.

17,447. W. M. HUSKISSON. London. An automatic submarine mine and sentinel.

17,466. W. WRIGHT and J. B. HAMOND. London. Improvements in the treatment of zinc produced by electrolysis.

17,493. J. B. C. DION. London. Improvements relating to thermo-electric batteries and to apparatus for use in the manufacture of the same.

September, 18 1893.

17,501. W. FIELDER. London. Improvements in, and connected with, alarum clocks, and electrical signalling appliances.

17,521. J. JACKSON and W. DIXON. Glasgow. An important method of illuminating by the electric arc.

17,526. R. J. CROWLEY and W. C. COX. Queenstown. Improvements in, or relating to, fac-simile telegraphy.

17,557. E. COMMELIN. Liverpool. Improvements in electric meters.

17,564. A. KOCH. London. Improvements in electric accumulators.

September 19, 1893.

17,603. A. S. ATWATER. London. Arc lamp.

17,605. W. S. FREEMAN. Otford. Improvements in dynamos and dynamo motors.

17,618. C. ERBEN and E. BERGMANN. Liverpool. Improvements in electric meters.

17,631. H. NEWMARCH. London. Improvements in, and connected with, alarm clocks and electric sound signalling appliances.

17,645. H. H. GRENFELL and O. MARCH. London. Improvements relating to the distribution and regulation of electric current.

17,646. T. W. NESS. London. Improvements in telephone switch operating mechanism.*

17,658. R. W. BARKER. London. Improvements in current conveyors for electric railways. (The Lawrence Electric Company, United States.)*

September 20, 1893.

17,666. W. I. G. LEWIS and E. J. BRADLEY. Newcastle-on-Tyne. Lithophonique porcelain shades for the electric light.

17,690. R. J. CROWLEY. Queenstown. Improvements in or relating to the transmission of electricity and sound along a conductor without a return circuit, and a means of reducing electrical resistance in the air, earth, or sea.

17,692. E. COUSTAU. London. An electric match.

17,729. A. KELVIE. London. An improved convertible combination lamp for electric light, gas, oil, or candle fittings for general advertising.

September 21, 1893.

17,735. J. A. MCNAUGHTON. Manchester. Improvements in the construction of electric appliances applicable to corsets.

September 22, 1893.

17,796. R. KENNEDY. London. Improvements in electric arc lamp regulators.

17,804. F. L. BERNERS and J. L. HIGGS. London. Improvements in, or connected with, secondary batteries.

17,830. G. ABBOTT. Tunbridge Wells. A new and improved galvanic battery, to be called a cartridge shell battery. (J. J. Pearson, United States.)

17,860. E. J. CLUBBE and A. W. SOUTHEY. London. Improvements in electrically propelled vehicles.

17,866. L. W. SCHÖFFER and G. E. W. SCHÖFFER. London. Improvements in apparatus for the electrolytical decomposition of brine and other liquids.

September 23, 1893.

17,874. H. WALKER. Birmingham. Improvements in globe-holders for gas, oil, or electrical purposes.

17,933. J. HOPWOOD. London. Automatic supply fuse for electric supply currents, and in apparatus connected therewith.

September 25, 1893.

17,972. A. MILLS. London. Improvements in make-and-break contacts for electric bells, fire and burglar alarms, and other purposes.

17,980. P. B. W. KERSHAW. London. Improved process and means used therein for the electrolytical production of gases.

17,981. J. DRACH. London. A magneto-electrical igniting apparatus.

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17,992. C. JOST. London. An improved composition, and the production therefrom of blocks, slabs, tubes, vessels, or like articles, more especially intended for the production of paving blocks or slabs, or conduits for electric cables.

September 26, 1893.

18,019. J. H. TUCKER. Birmingham. Improvements in electrical switches.

18,038. Sir C. S. FORBES, Bart. London. Improvements in microphones.

18,061. THE EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED) and P. H. BELL. London. Improvements in electric switches.*

18,066. W. R. LAKE. London. Improvements in and appertaining to adjustable supporters for electric lamps and other objects or articles. (O. C. White, United States.)*

18,067. W. H. SHARPLESS. London. An improved form of electric switch.

September 27, 1893.

18,115. F. J. BORLAND. London. A new or improved electric arc lamp, specially applicable for projecting purposes instead of the lime-light.

18,117. H. INGRAM and A. INGRAM. Liverpool. Improvements in brush holders for dynamo-electric machines and electric motors.

18,150. V. C. DOUBLEDAY. London. A portable secondary battery lamp for use in mines and other places. (M. Sussmann, Germany.)

18,165. A. A. GOLDSTON. London. Improvements in and connected with electric switches for series circuits.

18,170. J. S. RAWORTH. London. Improvements in electrical contacts.*

18,173. J. HARGREAVES and T. BIRD. London. Improvements in apparatus for the electrolysis of chlorides and other salts.

18,175. O. FRANZ and G. OTTO. London. Improvements in switchboards for telephone exchanges.*

September 28, 1893.

18,187. T. SLOPER. Devizes. Improvements in or relating to electric telephones.

September 29, 1893.

18,291. H. A. TAYLOR and J. A. L. DEARLOVE. London. Improvements in or appertaining to submarine telegraph and like cables.

18,323. H. H. LEIGH. London. Improvements in electric batteries. (A. Chevalier, France.)

23,101A, '92. C. A. J. H. SCHROEDER and H. E. R. SCHROEDER. London. Improved methods of recovering zinc from the waste products of galvanic batteries.

(Date claimed under Patents, Rule 19, December 15, 1892.)

23,101B, '92. C. A. J. H. SCHROEDER and H. E. R. SCHROEDER. London. New or improved galvanic batteries.

(Date claimed under Patents, Rule 19, December 15, 1892.)

September 30, 1893.

18,346. E. W. P. COMMENS. Birmingham. Improvements in electric switches.

18,363. S. O. COWPER-COLES and SIR B. W. WALKER, Bart. London. Improvements in electro-plating.

18,375. J. A. MONTEALEGRE. London. Improvements in or relating to the arrangement of electrical circuits and switches.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

14,124. HURD. Electromotors.

14,239. HOOKHAM. Electricity meters.

16,300. FREI. Electrolysis of fused electrodes.

16,335B. HARRISON. Magneto-electric generators.

16,335C. HARRISON. Electric bells.

17,091. CROMPTON and DOWSING. Insulating and supporting electric wires, &c.

17,039. BARRETT. Carbon electrodes.

17,877. ANDREWS and PREECE. Dynamo-electric machines.

17,878. ANDREWS and PREECE. Starting electric motors.

17,909. CHALLIS. Electric switches.

19,181. IMRAY. (Westinghouse Electric and Manufacturing Company.) Electric lamps.

19,404. RAWORTH. Cut-outs for electric generators, &c.

19,821. SIEMENS BROS. and Co. (Limited). (Siemens and Halske.) Current transformers.

19,834. BENNETT. Telephonic apparatus.

19,953. RICHARDSON. Electrodes.

20,348. BLACK. Electric battery cell.

20,418. KLERITJ. Magnetic water gauges.

20,700. JONES. Lighting trains by electricity.

21,243. WEBB and THOMPSON. Electric light cables and lamps.

22,038. CATHREIN. Incandescent electric lamps.

23,579. ZOBEL and BUCHMÜLLER. Electric incandescent lamps.

24,0-8. BROWN. Starting non-synchronous single-phase alternating current motors.

1893.

11,069. THOMPSON. (Ries and Another.) Telegraph wires, rails, pipes, &c.

11,077. PETERSON. Electric circuits.

14,910. JENSEN. (Sinding-Larsen.) Electrolytical decomposition.

15,110. PERRET. Electromotors.

NEW COMPANIES, STATUTORY RETURNS, &c.

OMNIBUS AND TRAMCAR ELECTRIC LIGHTING COMPANY (LIMITED). This Company was registered on September 28th with a capital of £60,000, in £5 shares, to acquire all or any part of the shares, works, undertakings, business, property and liabilities of the Universal Electric Lighting Company, to generate, produce, store, accumulate, and distribute electricity, electromotive force, or other similar agency for the purpose of lighting omnibuses, tramcars, cabs, and other vehicles, public or private buildings, manufactories, mines, ships, lighthouses, railways, and other places and things, to carry on the business of electricians, electrical engineers, mechanical engineers, and manufacturers of electrical appliances, &c. The subscribers (with one share each) are:—A. W. Stormont, 6, Cambrian-road, Richmond; A. L. B. Kerr, 5, Queen's Club-terrace, Kensington; W. J. Griffiths, 43, Finsbury-square, E.C.; J. F. Rogers, 108, Penton-place, Kennington, S.E.; J. A. Lloyd, 54, Florence-road, N.; H. H. Clayson, 27, Borthwick-road, Stratford, E.; and R. Wolfenden, 11, Great George-street, S.W.

HEAD, WRIGHTSON AND COMPANY (LIMITED).—The annual return of this Company, made up to July 1st, has been filed. The whole nominal capital of £210,000, in shares of £5, had been taken up, subscribed for, and fully paid, 98 share warrants of 20 shares each, 140 of 10 shares each, 200 of 5 shares each, and 494 of 1 share each, are outstanding, the value being £24,270. Share warrants representing 25 shares have been surrendered during the last financial year.

MADRAS ELECTRIC TRAMWAYS COMPANY (LIMITED).—This Company has recently entered into an agreement with the Electric Construction Company (Limited) for the supply of plant and materials for use in the construction of their tramway at Madras under a concession granted by the Municipality of Madras, with the approval of the Government. The price to be paid is £58,950, of which £19,650 will be satisfied by the allotment as fully paid of 19,650 shares of £1 each, Nos. 14,928 to 34,577 inclusive.

CITY NOTES, &c.

BRAZILIAN AND SUBMARINE TELEGRAPH COMPANY (LIMITED).—The accounts of this Company, subject to audit, show a profit sufficient to enable the Directors to recommend a final dividend of 3s. per share, making, with previous distributions, a total dividend of 6 per cent. for the year ended June 30, 1893, and also the payment of a bonus of 1s. per share, both free of income-tax, which together will amount to £26,000, leaving a balance of £10,533, of which amount £7,000 has been placed to the reserve fund, increasing that fund to £638,675, and £3,533 carried forward. For the purpose of paying the above dividend and bonus on the 19th inst., the Register of Transfers will be closed from the 10th to the 18th inst., both days inclusive.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended October 1st were £795, as against £786 for the corresponding period of last year, being an increase of £9. The total receipts for the half-year amount to £10,449, against £9,994 in the corresponding period of 1892, being an increase of £455.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts for the month of September are £3,000, as compared with £3,295 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The gross receipts for the month of September were £1,865, as compared with £2,011 for the corresponding period of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The Company announce the payment by warrants, on November 1st, of interest for the half-year ending October 31st, on their Four per Cent. Mortgage Debenture Stock. The transfer books will be closed from October 27th to November 1st, both days inclusive.——The traffic receipts for the month of September, 1893, amounted to £55,997, and to £55,710 in the corresponding period of 1892.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the month of September, 1893, amounted to £39,339, and to £42,585 in the corresponding period of 1892.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—This Company notify that on Tuesday, November 14, 1893, at noon, at the Company's offices, Winchester House, Old Broad-street, E.C., 345 Five per Cent. Mortgage Debentures will be drawn for payment on January 1, 1894. Notice will be given by advertisement of the numbers of the debentures drawn.——The Company also announce the payment by warrants, on November 1, 1893, of interest on their Four per Cent. Mauritius Subsidy Debentures in respect of instalments paid to October 31, 1893. The transfer books will be closed from October 27th to November 1st, both days inclusive.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The Directors last week issued a prospectus, inviting subscriptions for £25,000, in 2,500 Five per Cent. Perpetual Preference shares of £10 each, making, with £75,000 already issued, £100,000 out of a total authorised Preferential capital of £120,000. 10s. per share is payable on application, 30s. per share on allotment, and the remainder in calls not exceeding £2 a share at intervals of not less than three months. The list of applications opened on Tuesday and closed yesterday (Thursday).

W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).—Dividend warrants have been posted for the half-yearly interim dividend on the Preference shares at the rate of 7 per cent. per annum.

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WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended September 29, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,314.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the two weeks ended September 30th were £1,765, as compared with £2,491 for the corresponding period of last year.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Sept. 27.	Price Wednesday, Oct. 4.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 4. Highest	Lowest.
			TELEGRAPHS			£ s. d.			
£1,134,640	Stock	12/6	Anglo-American	50 51	50 51	5 7 10	Jan. Apr., July, Oct.	..	..
£2,932,680	Stock	25/0	Do. Preferred	92 93	92 93	5 18 3	" "	93	92½
£2,932,680	Stock	5/0	Do. Deferred	9¼ 9⅜	9¼ 9⅜	..	..	9⅜	9⅛
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	99 102	99 102	3 18 5	January and July	100	..
130,000	£10	3/0	Brazilian Submarine	11⅛ 12	11⅛ 12	5 8 4	Mar., June, Oct., Dec.	11⅜	..
£36,400	£100	5%	Do. 5 per Cent. Bonds	99 103	100 103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107 111	107 111	4 10 1	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	136 140	135 140	5 0 0	April and October	..	..
16,000	10	8/0	Cuba Submarine	11 12	11 12	6 13 4	February and August	11⅛	..
6,000	10	10%	Do. Preference 10 per Cent.	18 19	18 19	5 5 3	" "	18⅛	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2⅛ 3⅛	2⅛ 3⅛	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	8⅜ 9⅜	8⅜ 9⅜	5 5 3	" "	..	..
60,710	20	3/6	Direct United States	11⅜ 11⅝	11⅜ 11⅝	5 18 2	Jan., Apr., July, Oct.	12	11⅞
400,000	10	5/6	Eastern	15 15½	15 15½	4 3 10	" "	15½	15⅛
70,000	10	6%	Do. 6 per Cent. Preference	16 16½	16 16½	3 12 9	" "	16⅜	16⅛
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112 115	112 115	3 9 7	May and November	..	..
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	106 109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15½ 15½	15½ 15½	4 10 4	Jan., Apr., July, Oct.	15⅛	15⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	110 113	111 114	3 10 2	February & August	112½	..
£70 600	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	102 105	102 105	4 15 3	January and July	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	101 104	101 104	4 16 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101 104	101 104	3 16 11	February & August	102¼	..
£200,000	£25	..	Do. 4% Mauritius Sub. Debs.	103⅞ 106⅞	103⅞ 106⅞	..	May and November	105⅜	105
180,227	10	4.0	Globe Telegraph and Trust	9⅜ 9⅝	9⅜ 9⅝	4 13 8	Jan., Apr., July, Oct.	9⅝	9⅜
180,042	10	6%	Do. 6 per Cent. Preference	15⅜ 15⅝	15⅜ 15⅝	3 17 5	" "	15⅝	15⅜
150,000	10	5.0	Great Northern	20 20⅛	20 20½	4 3 0	Jan., April, and July	..	..
£20),000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	103 106	103 106	4 14 4	March & September	..	..
17,000	25	37/6	Iado-European	39 42	39 42	5 19 1	May and November	40½	..
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	3 6 8	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 108	5 11 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4% Guar. Debs. "Red" 1942	101 104	101 104	3 16 11	..	102¾	102½
11,802	8	4/0	Reuter's	4½ 5¼	4½ 5½	..	April and October	..	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6 per Cent.	115 120	116 121	4 19 2	" "	..	..
15,609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July	..	..
£260,900	100	5%	Do. 5 per Cent. Debentures	99 100	98 101	4 19 0	March & September	..	..
30,000	10	2/0	West Coast of America	2 3	2 3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	97 101	98 102	7 16 10	June and December	..	..
88,321	10	6d.	West India and Panama	1⅜ 1⅝	1⅜ 1⅝	..	..	1⅜	1⅛
34,563	10	6%	Do. 6 per Cent. 1st Preference	10 10½	10 10½	5 14 3	May and November	10⅝	10
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	9⅝	9½
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	106 109	106 109	4 11 9	June and December	..	..
64,242	15	4/6	Western and Brazilian	6½ 7	6½ 7	5 7 6	May and November	..	..
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5⅝ 6½	5⅝ 6½	..	..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1 1½	1 1¼	..	..	1½	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	..	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	104⅜	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	115 120	115 120	5 16 8	May and November	..	..
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	101 104	101 104	5 15 5	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	2 3	2 3	..	..	..	..
224,850	10/0	3½d.	Consolidated Telephone Const. & Maintenance	1/16 1/16	1/16 1/16	..	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/16 1/16	¼ ⅜	5 2 11	Yearly	¼	..
458,867	5	2/6	National	4⅛ 4⅜	4½ 4¾	5 5 3	June and December	4⅛	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14 15	14 15	4 0 0	" "	14¼	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	13½ 14½	13¼ 14½	4 2 9	" "	..	..
90,950	5	2/0	Do. 5% Non-Cumulative 3rd Pref.	5½ 5⅝	5½ 5⅝	4 13 0	..	5⅜	5⅛
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	112 114	112 114	3 18 11	January and July	113½	..
58,000	5	1/0	United River Plate	2 2½	2 2½	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	11½ 11⅝	11½ 11⅝	..	..	..	..
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½ 13	12⅝ 13¼	..	..	13½	13
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	5 5½	.. ..	..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
8,322	£5	..	House to House Electric	1½ 2½	.. ..	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	5⅛ 5⅜	.. ..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	6 6½	.. ..	..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4⅛ 4¼	4⅛ 4¼	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6 6½	6 6½	..	..	..	..
111,000	5	..	London Electric Supply	¾ 1	¾ 1	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6¾ 7½	6¾ 7½	2 15 2	..	..	..
£100,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	104 107	104 107	4 13 6	June and December	105½	105
6,452	£10	..	Notting Hill Electric	5 6	5 6	..	..	..	..
19,980	£5	9½%	St. James' and Pall Mall	6½ 6⅝	6½ 6⅝	..	..	6⅝	6½
20,000	£5	7%	Do. 7 per Cent. Preference	7¾ 8¼	8 8½	4 2 4	..	..	..
59,900	5	1/6	Westminster Electric Supply (fully paid)	5 5½	5 5½	3 3 8	..	5⅝	5½
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	2/1	Brush Electrical Engineering	2⅞ 3⅛	2⅞ 3	6 0 0	..	3	2⅞
75,000	2	6%	Do. 6 per Cent. Preference	2⅝ 2⅞	2⅝ 2⅞	5 1 1	..	2⅞	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107 109	107 109	4 2 7	March & September	..	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	3½ 4½	3½ 4½	..	January and July	4½	..
12,139	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	1¾ 2¼	.. ..	..	..	..	..
49,900	10	12/0	Electric Construction	1¾ 2¼	1⅜ 2	..	..	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜ ⅝	½ ⅝	..	..	½	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 2	1½ 1⅝	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½ 22½	21½ 22½	5 11 1	February & August	..	..
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	101 103	101 103	4 7 5	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	1 2	1 2	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/0 4/0	3/0 4/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	2 2½	2 2½	13 19 8	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	32 34	32 34	5 5 10	March and July	..	..
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	January and July	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	.. ..	.. ..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	¾%	City and South London Railway	34 36	30 35	2 2 6	May and November	30	..
37,500	£10	..	Liverpool Overhead Railway	5½ 5½	5½ 5½	..	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 804.—Vol. XXXI. FRIDAY, OCTOBER 13, 1893. PRICE FOURPENCE. *Annual Subscription (U.K.), 19/6*

NOTES.

Prof. Ayrton's letter, which will be found in our correspondence columns, coming as it does from one who not only has lately returned from Chicago, but who has given considerable attention to the testing of glow lamps, assures us that the tests which are being carried out in connection with the Chicago Exhibition are being conducted with great care and under able supervision. This we are glad to learn. We cannot, however, admit that we have condemned the labours of Prof. Thomas and his assistants; they will, doubtless, yield many interesting scientific results. Our criticism related to the prospect of the information obtained being of commercial and practical use. Prof. Ayrton asks why we object to the maintenance of a perfectly steady pressure. We reply that, for a scientific test, such a pressure is desirable, but that it does not correspond with the conditions of practice. Some day house-agents will advertise "a desirable mansion situated near a feeding point," and in such a house the pressure should be fairly steady. But even recording voltmeters show very considerable variations of pressure in most parts of London, and the minor variations which such instruments are unable to register, chiefly on account of the inertia of their moving parts, probably have a marked effect on the life of lamps. We do not see how it is possible to specify a variation of pressure. The Board of Trade impose limits, but the nature of the variation, and, what is most important, the duration of the periods of high pressure, affect the life of lamps, not the mere limits.

We are not at all sure whether, as Prof. Ayrton suggests, the removal of lamps to the photometer bench will cool them "as in practice." A fairly long test seems to be necessary, because it is only by the behaviour of long-lived lamps that we can judge of the economy of forcing them. The short lives which Prof. Ayrton advocates depend on the falling-off of candle-power, and this falling-off is undoubtedly greater when the lamp is forced. If there are any lamps which maintain their candle-power even at a slightly increased consumption of energy, their long and steady lives may offer some advantages. But 360 different lamps, limited to 40 of each voltage, or 80 of each make, are not, we think, sufficient. Do not the different batches of lamps turned out, even by makers so careful as the Edison and Swan United Company, differ very considerably? and we should imagine that with the unsettled state of the lamp industry in America, variations between batches would be almost as great as differences between different "makes."

A table intended to show the comparative cost of gas and electric light will be found in another column. It is said to emphasise the information in as lucid a manner as it can be stated. It was addressed to an Association of Gas Managers, who are, no doubt, very clever men, and took it in at a glance, but we must confess that we spent some time in calculations and cross-checking before we understood it. There is an attractive symmetry about it, and the explanation, which we believe to be necessary, will be found in a footnote to it. We are fully cognisant of the rosy optimism of many electrical authorities who declare that electric light is already as cheap as gas, but we have always been opposed to these sanguine calculations. A fairly good rule was, to multiply the number of pence per unit by ten, to get the equivalent price of gas. For example, electric supply at 6d. is equivalent to gas at 60d. or 5s. per thousand cubic feet. This assumes about 4·17 watts per candle for the glow lamp and 2·4 candles per cubic foot for the gas burner. Thus, an 8-c.p. lamp taking 33·3 watts consumes one unit in about 30 hours, giving 240 candle hours for 6d. Sixpennyworth of gas, on the other hand, at 5s. per thousand is 100 cubic feet, and this at 2·4 candles per cubic foot gives the same amount of light.

The table by Mr. Terrace assumes gas at 2s. per thousand, and the costs of 3,333 candle-hours with five different kinds of burners are given. The burners "as commonly used" are put at only 1½ to 2 candles per cubic foot. The obscure columns on the left-hand side of the table give the "number of units said to be equivalent to 1,000 cubic feet of 16 candle gas," and the cost at 6d. per unit. Ten units are said to be "allowed by the Board of Trade." What the Board of Trade has got to do with glow lamps we fail to comprehend. We are tolerably familiar with the doings of the Electrical Department of the Board of Trade; we doubt even that Mr. Terrace has any private information from the Department, but no number of units is "allowed" or "said to be" allowed by the Board. Reducing this mysterious allowance to figures, we find that it implies running a lamp at 3·33 watts per candle. Until the price of lamps was reduced this would have been generally considered a little too high pressure, but

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Prof. AYRTON now recommends about 3 watts per candle. "Practical men," gas managers, we presume, are said to "estimate" 12½ units to be equivalent to 1,000 cubic feet of gas. This means, according to the suppressed assumption on which the table is based, 3·75 watts per candle. This is better, but we took more than 4 watts. "One-sided advocates say," according to this high gas authority, 6 units. Possibly our idea that the 3s. means the cost of 3,333 candle hours is wrong, but, assuming that it is right, since the table is otherwise incomprehensible, 6,000 watt hours yield 3,333 candle hours; therefore the lamp must give 1·8 watts per candle. This is perfectly absurd. We greatly regret the over-confident and careless comparisons which have been made by electrical engineers, and which have very properly been criticised by the gas journals; but we challenge Mr. TERRACE to give the names of his one-sided advocates who recommend 1·8 watts per candle; or invite him to explain his table.

IN volunteering advice to young couples who are called upon to decide whether or no they will have the electric light, the *Pall Mall Gazette* admits that the light is much cleaner than gas, but observes that "the rent of the meter will be at least £1 a year," and that "the popular idea of lamps lasting a thousand hours is altogether a myth. Some may possibly do so, but many do not, and some last but a few weeks." Speaking of hours and weeks in the same breath is rather ambiguous. Six weeks contain about a thousand hours; but reckoning an average of two hours a day, six weeks represents only eighty hours of lighting. This is hardly fair to the manufacturing monopolists, who, with all their severity towards small contractors, have been generally ready enough to exchange lamps that have, through no fault of the consumer, broken down after an unduly short life. "Meanwhile, seeing that each light costs about four shillings, to replace them frequently is an expensive matter, and adds much to the cost of the light." This might pass for one of the usual careless misstatements of daily papers when they deal with matters even indirectly connected with science. But immediately facing this is a note, abstracted without acknowledgment, by the way, from the second page of our last issue. The only excuse for the error (the borrowing of a note is a trifle) is that the one is in a column of gossip and the other in "Science Notes."

THE adoption of a frequency of only forty alternations per second for the Derby electric supply is a step which, however defensible it may be on certain grounds, cannot be said to follow the lines of general English practice. The whole question involves, of course, the choice between convenience in alternate-current motive power distribution in its present imperfect state of development, and the plant efficiency of the generating and transforming machinery. The system is one of simple single-phase, and the introduction of a frequency of less than half the common figure will no doubt simplify matters where alternate-current motors have to be adopted. But, at the same time, it cannot have escaped the engineers who have designed this station, that there is rather a high price to pay for practice of this sort. Far-sightedness is an excellent quality in central station designers, and it is always well to provide for the demands of a few years' time. But it is possible to see too far; to cast one's eyes so far into the future as to forget the immediate claims of the present. Motive power will have to be provided by central stations in abundance, in a few years time, there is no doubt; but is it likely that the demand for the present and immediate future will justify such a departure from ordinary practice? Considering the possibility of a motor being in the meantime invented that will work with ordinary frequencies, would it not have been better to pay more attention to the lamps and to the plant efficiency of the machinery?

THERE is one element of danger in the penny-in-the-slot meter as applied to gas consumption which has been rather overlooked, and which is absent on electric lighting circuits, namely, the risk of gas escapes and explosion which arises from automatically cutting off the gas supply without closing the separate gas taps at the burners. When the gas is cut off at the meter, and afterwards turned on again by the dropping of the necessary penny into the slot, a forgotten gas jet may lead to very serious consequences, unless, indeed, each individual gas burner is to be provided with an automatic valve.

AN enterprising American has started a school of applied electricity which will be "conducted entirely on the correspondence method." This is surely the nemesis of the cramming-up-for-examination system; "students" stuffed with paper, fed on science, falsely so called, without ever seeing, far less handling, apparatus! When we have reached a stage at which swimming can be taught to perfection on a blackboard, and when the sight of the chemical formula for bread will satisfy the pangs of hunger, but not till then, will the paper age or *astræa redux* of technical education succeed in fulfilling any useful purpose.

INVENTORS not infrequently reveal a depth of unconscious humour in the products of their ingenuity, but rarely do we come across such an invention as that which has recently made its appearance in France in the shape of an automatic apparatus for preventing a consumer placing more than the proper load on his lighting circuit. In Brighton Mr. WRIGHT places a maximum recording instrument on the mains, and by a very simple system, which we described not long ago, a great concession is made to consumers, while the load is equalised and considerably increased. In Leeds it was proposed to allow the consumer to do what he pleased up to the very uncertain limit fixed by the main fuses. But the French inventor has decided otherwise, and elects to place in the circuit an electromagnetic device which will absolutely prevent more than the proper number of lamps being run at any one time. This would be bad enough if the device cut out the lights and left the would-be customer in darkness, as was threatened at Leeds; but the humour of the inventor leads him to perpetrate a more truly awful invention. When the extra lamp is put into the circuit in which it has no lawful

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place, an ingenious arrangement of springs and electromagnets causes the current to be alternately switched on and off again in rapid succession, thus making an irritating flicker in the lamps on the whole circuit controlled by the regulator. Imagine the state of affairs in, say, a crowded hotel, brought about by someone accidentally or purposely placing an extra lamp on the circuit, or by a bad fault in the wiring. How long the "alternate extinction and relighting" of the lamps would continue we cannot say; except that it would be until the machinery in the regulator had run down. When that stage was reached a metal bob in the exhausted regulator would drop forward and put an end to the agony by total and uninterrupted darkness. But this stage would not have been reached till 2,700 fluctuations of the light had been inflicted on the distracted and unhappy consumer. The idea must have originated in the well-known phenomenon attending the presence of water in a gas pipe.

Mr. A. A. Voysey has announced in a contemporary a "new danger." It consists of a combination of a table-cloth of fluffy material interspersed with fine metallic threads, and a neighbouring thunderstorm. The metal threads are "acted upon inductively by the lightning discharges," and the fluffy material is set on fire. Mr. Voysey advises persons who have such table-cloths, and other "combinations" that are "capable of becoming dangerous during a storm," to "take a quiet walk round his premises during or after any very severe thunderstorm." To destroy such table-cloths would be a feeble expedient. Fashion in her irresistible progress may dictate the use of such fabrics, but does not science also march onward? In these days of grandmotherly interference by county councils, municipal authorities, and Parliament, with our private concerns, should not "something be done"? A complete metallic cage might be built round the house, but this is clumsy. A better way would be to pass a short Act empowering the Board of Trade to make regulations for securing the safety of the public. A schedule of fluffy materials would be given, and a minimum impedance in milli-henrys per square metre of metallic ornament would be ordered. At last there would be some use for the secohm-meter—no household—or, at all events, no draper's shop—should be without one. Mr. Trowbridge's observations, which are recorded in another column, suggest that the triple combination of electric wires, leaky gas-pipes, and a thunderstorm is fraught with danger, but here even the sechom-meter or a lightning protector seems useless. The remedy, however, is simple—remove the gas-pipes.

California Midwinter International Exposition.—We have received particulars of an exhibition which it is intended to hold at San Francisco next December. The exhibits are to be of a general and international character.

Erratum.—Throughout the article on "Iron for Transformers" which we published on page 623, last week, the expression $S\,H\,d\,I$ should read $\int H \,.\, d\,I$, this expression giving the cyclic integration of the magnetising force with respect to the intensity of magnetisation.

Bristol.—A Bristol newspaper complains of the heavy character of the arc-lamp poles, which, it says, are quite unsuited to the narrowness of the streets. But it consoles itself with the reflection that there is some excuse for these massive castings "if they are taken as a symbolical assurance that there is no fear of a breakdown" of the electric lighting plant.

Electric Light in H.M. Navy.—Opportunity is being taken in Chatham Dockyard to have the electric lighting arrangements of the whole of the first-class armoured battleships fitting and preparing for sea improved. The electric lighting of the ships is being taken in hand by private electrical engineering firms, the battleship "Howe" being already completed. New electric lighting apparatus will also be fitted to the battleships "Monarch" and "Agincourt."

A Street Conflagration.—Occasionally, but very rarely, it will happen that circumstances combine to produce disaster as they have recently done on the electric tramway of Budapest. A large carboy of benzoline fell from a cart on to the road and, becoming fractured in the fall, poured a stream of highly inflammable fluid over the roadway and into the conduit of the electric tramway. It only required the sparks from the collector of a passing car to ignite the spirit, to cause a brilliant and dangerous conflagration. Luckily, however, the benzoline burned itself out in ten minutes, doing but little damage, though causing for the time being a considerable panic among the passengers of the ignited tramcar.

Electric Distribution of Time.—M. Henri Campiche, of Geneva, has devised a system of electric distribution of time, in which he has paid special attention to the simplification and cheapening of the distributor. By this means the inventor hopes to adapt his system to small local groups of clocks, as well as to extensive circuits. The distributor consists merely of an electrically-propelled pendulum, which actuates a pawl and ratchet wheel, and thereby causes an electrical impulse to be sent through the circuit every two seconds. The clocks are placed in parallel across a two-wire main. Simplification of the distributor may be desirable; but the question on which the system will stand or fall will be not simplicity but accuracy.

The Moving Sidewalk at Chicago.—One of the features of novelty in the Chicago Exhibition is the sidewalk or platform, which is maintained in constant motion, for the purpose of conveying visitors about the Exhibition grounds and buildings. It is interesting to notice the comparatively small amount of power which is required to keep this chain of platforms in motion. The dead weight of the entire train when unloaded is 500 tons, and the addition of the full complement of 4,000 passengers brings the load up to about 800 tons. We understand that not more than 105 E.H.P. is absorbed in moving this mass. The fact that a larger amount of power is unnecessary is undoubtedly due to the absence of stoppages—or, rather, startages—and to the low velocity of movement.

Electric Railway Tests.—The following figures relating to the Cedar Rapids (Iowa) Electric Railway may be of interest. The station plant consists of three Reynolds-Corliss condensing engines, three return tubular boilers, one 300-kilowatt, and two 80-kilowatt Thomson-Houston multipolar generators. The line is six miles long, with some $5\frac{1}{2}$ per cent. gradients. On August 3rd there were operated during the test two 34ft. double truck interurban cars weighing 20,000lb. each, equipped with two 50-H.P. T.H. motors each, one express car weighing 12,000lb. with the same equipment, and eight 16ft. cars weighing 9,800lb. each, equipped with one T.H. motor. The coal burnt was soft Iowa slack. The total car miles run during the test were 1,325, and the car miles run per ton of coal were 275.

The Chur Electricity Works.—The town of Chur is another addition to the many using Oerlikon dynamos, and it has the usual equipment of high-pressure alternators and transformers. Power is obtained from the falls of the River Rabinsa, where a head of about 220ft., supplying about 400 H.P., is available. There are at present some 3,000 8-c.p. lamps on, and a few arcs for public lighting, which have each their own transformer, and are thus entirely independent of one another. Motors are also in extensive use, and the Oerlikon non-synchronous type is generally used.

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There is one motor of 100 H.P., and several of 1-9 H.P., the 100 H.P. motor being synchronous, and started by a small synchronous one. All the motors are on a special circuit. The station has been running since November, 1892.

Manganese Steel.—In a Paper read at the Chicago meeting of the American Institute of Mining Engineers, Mr. R. A. Hadfield gave some interesting information about manganese steel. A large magnet in the Edison laboratories, said to be capable of lifting nearly a ton weight, would not attract even a piece of manganese steel weighing but a few grammes. When manganese is present to only 9 per cent. the material is non-magnetic, taken in bulk, though its drillings are influenced considerably, thus indicating that to detach the material, or break it up into smaller masses, enables the magnetic force to exert its influence. This, however, does not apply, or only very slightly, to 13 per cent. drillings. Some years ago the writer noticed that some manganese steel car-wheels which had been running for a considerable period were, after their return, more susceptible to magnetic influence. It would seem that the constant vibration experienced by such articles had to some extent influenced the particular property under consideration. Manganese steel, when worked hot, can be reduced to the thinnest sections or drawn to fine wire (No. 32 B.W.G.). For this, however, great care is required; but ordinary gauges, to about No. 20 B.W.G., present no special difficulty. Messrs. Willans and Robinson, of Thames Ditton, have used 1½ ton of the manganese steel for resistance-coils in connection with a special electric plant.

Envermeu.—The little town of Envermeu, in the department of Seine-Inférieure, has an interesting electric light plant. The central station was commenced in September, 1892, and started running by November of the same year. Water power is employed to drive the dynamos, which are Gramme type machines giving 20 amperes at 300 volts at a speed of 1,020 revolutions per minute. These machines are used, partly to charge storage batteries, and partly feeding directly on to the supply mains. The storage cells are of the Verdier pattern, having each a weight of 15 kilogrammes, and a capacity of 10 ampere-hours per kilogramme. From the generating station an aërial line, consisting of three bare wires, conveys the power to the centre of the town, a distance of 1,200 metres, from which point a number of independent circuits radiate. The main conductors are of high conductivity copper, 6·3mm. in diameter (about No. 3 S.W.G.), and the middle wire is 4mm. in diameter (No. 8 S.W.G.). The station is designed to supply a maximum of 1,500 candles, or 150 glow lamps; and the load, which has now attained this value, is distributed in the following manner: there are six circuits of street lamps, each under separate control, amounting to 36 lamps; and the several circuits of private consumers' lamps make up the remainder. The rental of the former is at the rate of 25fr., and of the latter at the rate of 35fr. per lamp per annum; and the Supply Company undertakes house wiring at the rate of 25fr. per lamp.

Lightning and Gas Escapes.—During a recent visit at a summer hotel which was lighted by incandescent lamps, writes Mr. J. Trowbridge in a Paper in the *Phil. Mag.*, on "The Oscillations of Lightning Discharges and of the Aurora Borealis," I was much interested to observe that the lamps blinked at every discharge of lightning, although the interval which elapsed between the blinking and the peals of thunder showed that the storm was somewhat remote. This effect was doubtless due to induction produced by the surgings of the lightning discharges, for in heavy and in near discharges the lights were completely extinguished, although no fuses were burned. My observation of this effect of lightning upon electric light circuits also leads me to believe that the system of carrying electric light wires along gas-fixtures where both electric light fixtures and gas fixtures are combined is fraught with great danger. If there is any leakage of gas at the joints of the gas-pipes, or through a sand hole in the casting of the pipes, electric sparks, arising through resonance effects, or from the ordinary passage to earth of an electric charge brought into the building by the electric wires, can ignite the escaping gas and produce a mysterious conflagration. Such a conflagration was averted in the hotel in which I noticed the blinking of the lamps only by the careful scrutiny of an attendant, who noticed a jet of gas from a pinhole in the gas fixtures impinging on the woodwork. During the storm a minute electric spark had ignited the escaping gas. Electric light wires and gas pipes should never be contiguous, for no lightning-guard or protector can ensure that minute sparks, due in some cases to resonance effects, may not arise.

The Junior Engineering Society.—The annual general meeting was held last Friday at the Westminster Palace Hotel, the retiring Chairman, Mr. Sidney Boulding, M.I.M.E., in the chair. From the Council's report of last session, which was read by the secretary, Mr. Dunn, it appears that the Society continues to be well fulfilling the objects for which it was formed. The total membership now numbers 330, an increase of 13·4 per cent. during the session. It was stated that Mr. John Wolfe Barry had accepted the presidency for the ensuing session, 1893-4. Eight meetings had been held, and fourteen visits to works, &c., arranged, exclusive of the summer excursion to the West of England. The average attendance at the meetings was 56, and at the visits 65. The Society's premium had been awarded to Mr. R. W. Newman, Assoc.M.Inst.C.E., for his Paper on "The Sanitary Engineering of Dwellings." The balance-sheet showed receipts as £320. 19s. 4d., and expenses £306. 1s. 8d., leaving a credit balance of £14. 17s. 8d. On the motion of the Chairman, the report and statement of accounts having been adopted, and a vote of thanks passed to the retiring officers, various motions in reference to revision of rules were discussed. It was agreed that under certain circumstances the Council should have the power of remitting members' subscriptions; a system of compounding for subscriptions was also approved of. The election of officers and council for the ensuing session resulted as follows:—Chairman, Percy J. Waldram; vice-chairman, Henry J. Young; hon. librarian, H. B. Vorley; hon. auditors, F. W. Page, W. H. De Ritter; council, R. W. Newman, W. H. De Ritter, Harry Fraser, P. Marshall; remaining in office, P. G. Bowen, Basil H. Joy, Ernest King, Loftus Perkins; secretary and treasurer, W. T. Dunn.

Electricity and Vegetation.—At a recent meeting of the Physical Society of Geneva, a Paper was read by Prof. R. Chodat on "The Action of Electric Light on Vegetation." To discover whether germination was really quicker in plants under the influence of electricity Prof. Chodat made the following experiment:—A certain number of bean seeds were placed in water until the roots became visible. Fourteen seeds in all were used; they were divided into two lots, each of these being identically the same as regards weight, size, and appearance. Each lot was placed in a tub containing sawdust, and each was regularly watered, while the conditions of heat and light for each were identical. One of the tubs was then placed in communication with a Holtz machine, and was electrified, the first day for 40 minutes, the second for 2½ hours, the third day 3½ hours, the fifth day for 4 hours, and the following days for 3 hours up to the eleventh day. On the fourth day the leaves began to appear in the electrified tub, while no sign of a leaf was apparent in the other. On the fifth day the difference was still more marked, for the leaves and stems began to take an upright position, though no activity was manifest in the second tub. On the seventh day the non-electrified seeds began to put forth buds. A second series of experiments was conducted to ascertain the influence of electricity on the oxalis. Some specimens of this plant were placed in connection with the electrical machine, while some others were placed away from it. When the former lot had been electrified they were covered with a wooden box, which completely shut out the light. The second lot was covered in like manner. At the end of twenty minutes the two pots were examined; the electrified oxalis had kept their normal position, while the other plants were in a drooping condition. The same effect has been tried on this plant at the end of the day. When twilight came on one pot was electrified, while the other was not. Soon the difference became apparent, for the plants in the first pot remained awake till long after the other had closed its buds. It is an interesting fact that the sensitive plant is not affected by these electrical influences.

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AN EXAMINATION OF PROF. LODGE'S ELECTRO-MAGNETIC HYPOTHESIS.

BY PROF. J. H. POYNTING.

(*Concluded from page 608.*)

I have now given an account of the main features of Dr. Lodge's hypothesis as to the nature of electric charge, magnetism, and current, and I have done this at considerable length because I propose to discuss the foundations for the hypothesis, and to see if they are sufficiently firm to bear the superstructure. To recapitulate the main features, we have a double ether consisting of equal + and − portions attached in some sort of way to matter as a framework—elastically in dielectrics—loosely, with a kind of viscous connection in conductors. The two ethers always move in opposite directions along the lines of electric force, and in dielectrics they store energy by their displacement past the material framework, while in conductors they only dissipate it during the displacement. The ethers are cellular in construction, and the cells are capable of rotation, this rotation constituting magnetism, and the accompanying rotational energy being magnetic energy. The axes of rotation are along the lines of magnetic force. The cells roll on one another as if quite rough in dielectrics, and as if lubricated with viscous oil in conductors, and they are alternately + and −, and moving in opposite directions, a clockwise moving + cell giving the same direction to the magnetic force as a counter-clockwise - cell. Current is, according to Lodge, slip of these cells against each other, but according to the interpretation I have given of his theory, current is a double and continuous procession of the cells in a conductor, with the consequent rotations.

The hypothesis is avowed by its author to be an attempt to obtain a mechanical explanation of electric and magnetic phenomena. He uses the main idea of Maxwell's well-known model, but replaces Maxwell's duality of magnetic wheels and electric "idle" wheels by a duality of electric wheels. It is, perhaps, open to question whether this is really a simplification, but the attempt was very well worth making, for it is only by variation and natural selection that the mechanical model will be suited to its environment in the electric world.

It is, I suppose, useless to look for any other than a mechanical hypothesis as final. Probably because we are able to picture mechanical processes, able to think of ourselves as seeing what goes on, seeing kinetic energy manifested in the moving parts, able to think of ourselves as part of the connecting machinery, feeling the stresses, and helping to make the strains, we have come to regard mechanical explanations as the inevitable and ultimate ones.

Thus, though the old mechanical hypothesis of light is for the present discarded in favour of an electromagnetic one, I suppose no one is content with the present position; but we are all looking forward to the time when, by mechanical explanation of electromagnetism, light shall once more become mechanical. Nevertheless, it is well to bear in mind that all such explanations are merely hypothetical, and may at any time have to be discarded, as the solid ether light hypothesis has been discarded. Indeed, they are solely of value as a scaffolding enabling us to build up a permanent structure of facts, *i.e.*, of phenomena affecting our senses. And inasmuch as we may at any time have to replace the old scaffolding by new more suitable for new parts of the building, it is a mistake to make the scaffolding too solid, and to regard it as permanent and of equal value with the building itself. It is on this point that I find most cause for disagreement with Prof. Lodge. He appears to me to regard his hypothesis as inevitable and permanent, or at least as approximating to the permanent and inevitable. The scaffolding, in fact, is made as important as the building. It behoves us, therefore, to examine into the security of its foundations.

We may take the hypothesis as based on two statements:—

I. Regarding electricity at rest, "Whenever we perceive that a thing is produced in precisely equal and opposite amounts, so that what one body gains another loses, it is convenient and most simple to consider the thing not as generated in the one body and destroyed in the other, but as simply *transferred*" (p. 9).

II. Regarding electricity in motion: "Magnetism is nothing more nor less than a whirl of electricity" (p. 171).

Let us examine some cases which should come under the first statement.

We may regard the upper and under surfaces of a vessel of liquid as respectively positive and negative, and if we measure them by their projections on a horizontal plane they are equal and opposite element by element. We clearly cannot create a positive without an equal negative. Bring the two elements together, and they neutralise each other, for both cease to exist. We have no idea here of something transferred.

Or, take the case of a rotating cord. Its two ends, as viewed from the outside, have equal and opposite properties, as may be seen at once if we think of them as brought close beside each other. If the rotations were transferred to one and the same body the net result both to themselves and to the body would be no motion. Or if the cord were cut away in slices, bit by bit, when it is all cut away the two ends have come together, and have, in a sense, neutralised each other. Here again we think of nothing transferred.

As a third case take a magnet. We always create equal and opposite poles at the same time with mutually neutralising properties, and to bring this within Dr. Lodge's statement we have only to consider the magnet as made up of two bodies joined together in the middle. Or perhaps we might take the case of the creation of N. and S. poles by the breaking of a magnet. No one has yet made a displacement or transfer hypothesis for magnetism except for the purpose of illustration. This, by the way, is rather remarkable, for magnetism with its re-entrant tubes of induction is so much more ready to lend itself to such a hypothesis. We seem to have finally made up our minds that electric is strain energy, and that magnetic is rotational energy, and we do not even consider the alternative of magnetic as strain and electric as kinetic energy. No doubt the existence of magnetic rotation of the plane of polarisation of light strongly suggests the rotational nature of magnetism, but we can hardly claim any explanation of the phenomenon yet put forth as complete, and certainly none is exclusive. The other facts would possibly be equally well explained if we thought of electric tubes of induction as strings of wheels with their spindles along the axis of the tubes, and magnetic tubes as lines of flow of ether or of two ethers, with a certain displacement coefficient, greater in diamagnetics, less in paramagnetics. I do not put this forward as worth following out, but merely to illustrate the contention that we need not necessarily think of + and − electrification as due to a longitudinal transfer of something. It appears to me quite possible then to symbolise the positive and negative charges facing each other across a dielectric in other ways than by the transfer of something from one towards the other.

Turning now to the second fundamental idea, Ampère's hypothesis, that a magnetic molecule is a small closed electric current, this is really closely connected with the idea that there is something moving in the direction of an electric current and constituting the current. It is in fact dependent on our acceptance of the first idea. For consider what an Amperian current is phenomenally. There is no resistance, and therefore no heat developed, and no fall of potential; there is no junction, and therefore no Peltier effect; there is no break, and therefore no chemical effect. The one effect left is the magnetic one. If, then, we take away the idea of some substance whirling round and round in a channel, all that we have left is a little permanent magnet. In other words, we explain the constitution of a magnetic molecule by supposing that it is a molecule having a magnetic constitution.

It is true that if we get a bundle of lines of magnetic force and tie them together with a perfectly conducting cord with its ends joined up we have a permanent magnet, for no more and no less lines can pass through the ring of perfectly conducting stuff. But this does not really explain. It does not show that the unknown is a case of the known. For a perfect conductor is far more difficult to think of than a permanent magnet.

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It is getting time that these so-called "perfects" were abolished from Physics. We have to deal with matter as it is and not as we should have had it if we had been consulted as to how it should be made in order to simplify our equations. The perfect gas has nearly gone and I shall be glad to see the perfect conductor preparing also to depart.

If, however, we grant substantiality to the electric current, we are met by a difficulty in connection with Ampère's hypothesis which, at any rate, requires examination.

Let us suppose that we have a circuit of self-induction L and resistance R, and let N be the number of outside lines passing through the circuit. If E is the E.M.F. of the battery kind in the circuit the current equation is

$$E - \frac{d}{dt}(L\,C). - \frac{d\,N}{dt} = C\,R.$$

If $E = 0$ and $R = 0$ we have an ampere circuit for which

$$\frac{d}{dt}(L\,C) + \frac{d\,N}{dt} = 0,$$

or

$$L\,C + N = \text{constant}.$$

In words, the total number of lines of force threading the circuit is constant.

If, now, N increases, either L or C must diminish. In order that L may diminish the circuit must contract and pinch in, as it were, the lines of force. But meanwhile, since the total is constant, the number of lines passing through the same area is increasing, and we should expect the spin, therefore, to increase and tend to make the tubes of force widen out. That is, there would be resistance to the contraction. The contraction is contrary, too, to our ordinary experience of a circuit with a current in it, for such a circuit tends to expand. If, on the other hand, the circuit is rigid, L is constant and C must diminish. If, as I gather from the general tenor of Dr. Lodge's work, the ampere circuit is one of the ether cells peculiarly constructed or at least of the same order of magnitude, a diminution of C means a diminution of spin of this cell. But the total number of lines of force through it is constant, which seems to imply that the spin remains the same. This seems to force us to suppose that the ampere circuit is *not* of the order of the ether cells, but larger, so that it may include within its contour a number of these cells. Then when N increases, C round the boundary may diminish, and still $L\,C + N$ be constant, for the internal wheels may be spinning at the same rate as before, but the external wheels more slowly, the current being a function of their difference. It would require further examination to see whether the total spinning energy could thus be accounted for. At first sight it would appear that that energy is diminished by the lessening of C just when we want it to increase.

If we are to suspend our judgment as to the substantiality of electricity, and are not as yet to conclude that a current is a rushing round of a thing of some kind, we are bound also to suspend our judgment as to Ampère's hypothesis, and if we are in this state of suspense, and, for my own part, I must confess to being so, Dr. Lodge's hypothesis and its accompanying models are to be used rather as illustrations—as analogies—than as ultimate solutions. For the purpose of illustration they are of the greatest value. Like a bank reserve, ready in case of emergency to cash the symbolic bank-note, they are in the background in the mind ready to turn into mechanical reality the ordinary electromagnetic symbols, such as lines of force, which are, I think, much more easy to deal with, but which are, doubtless, wanting in reality.

Perhaps Dr. Lodge may consider that my criticism is somewhat carping, in that I have nothing constructive to put in the place of the hypothesis to which I object. But I believe that the time has hardly come for ultimate mechanical construction, and that at present progress is more likely to be made if we are content with an electromagnetic explanation, if we merely carry down to the molecules and their interspaces the electric and magnetic relations which we find between large masses and round large circuits, and leave the ether out of account. I believe that we may symbolise electric and magnetic actions by means of lines of force and their motions in a way which allows us to think clearly of the phenomena, and though the ultimate nature of the lines of force is unknown, we can only say the same of the ether. In the application of these lines of force to the molecules, and their constituent atoms, there appears to be hope for some kind of explanation of the chemical phenomena of the circuit and of the distinction between electrolytic and metallic conduction. The difficulties in the way are by no means small, as everyone knows. I may, at some future time, attempt to set forth some of the difficulties as they occur to me, in the hope that a plain statement of them may lead some reader to help in their solution.

PRIMARY BATTERIES IN THEORY AND PRACTICE.*

PART I.

BY W. R. COOPER, M.A.

Like many other great discoveries, the voltaic cell was the result of mere chance, due, indirectly at least, to the dead frogs of Galvani. The theory which Volta framed in explanation of the observed phenomena led him about twenty years later, in the year 1800, to construct his voltaic pile, and also the "crown of cups," or the voltaic element in its simplest form. Cruickshank (in 1801), Wollaston (in 1815), and Hare (in 1822) introduced various forms which were only slight modifications of Volta's cell. In 1830 Sturgeon discovered the value of amalgamating the zinc plates, but it was not until 1836 that any great improvement was effected, when Daniell and Grove brought out the respective cells which are still known by their names. Six years later Bunsen introduced the carbon element in a practical form, and, after the lapse of another twenty-six years, the Leclanché battery appeared in 1868.

Having briefly glanced at the history of the subject, let us now turn to a few points in detail.

Constitution of the Voltaic Cell.

The first question that suggests itself is:—What are the essential constituents of a cell? Experience points to the conclusion that at least three elements are necessary, one of which must be a conductor, and one an electrolyte, the third belonging to either class. It is further necessary that two of these elements should be capable of chemically acting upon each other.

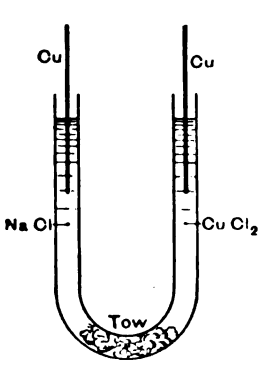

Fig. 1.

Here we must distinguish between two possible modes of chemical action. A chemical change may take place (1) such that the energy liberated is exerted wholly at the spot where the reaction occurs; or (2) such that the energy is transferred elsewhere, and is there capable of utilisation. The first includes ordinary chemical combination; the second is that which is essential to the voltaic cell. For example, if impure Zn is immersed in dilute H_2SO_4, $ZnSO_4$ is formed, and hydrogen is evolved: energy is given out, but it is not transferred. If a strip of copper is also immersed in the acid, and the external circuit completed with the zinc, a larger quantity of $ZnSO_4$ is formed, and hydrogen is evolved at the copper as well as at the zinc: here there are two portions of energy, the one being

* Paper read at a Students' Meeting of the Institution of Electrical Engineers, May 19th.

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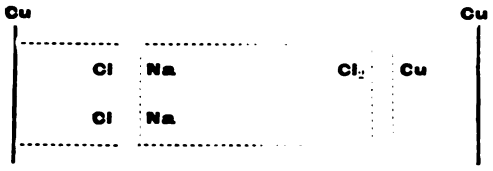
transferred and the other not transferred. If, now, the zinc is amalgamated and joined up to the copper, the whole of the energy given out is transferred, and the useless energy is avoided.

In the batteries that are usually employed the cells consist of two conductors and one or more electrolytes. But, as far as current is concerned, one metal and two electrolytes will give the desired result. For example, a cell may be formed by a U tube, one limb containing NaCl, and the other $CuCl_2$ (separated by tow, as shown in Fig. 1), the plates being of copper. The copper reacts upon the NaCl to form cupric chloride, and the liberated sodium reduces the cupric chloride in the other limb, copper being deposited on the copper plate as indicated below :—



The cell just described depends for its action upon the decomposition of one of the electrolytes by the metal. Becquerel's cell is often given as an instance of the production of current by the interaction of two electrolytes. A porous pot filled with HNO_3 is placed in an outer vessel containing KOH, platinum plates being used for both the poles. The production of the current will be discussed later on in this Paper.

It is hard to give anything like a complete definition of a cell. In all probability the solution of every metal is accomplished by voltaic action, the third element being obtained either by impurities in the metal itself, or by the solvent acting in two capacities at the same time.

Seat of the E.M.F.

The origin of the E.M.F. in the voltaic cell has given rise to many ingenious hypotheses, and has formed the subject of hot scientific warfare, which is not altogether at an end. We need here only consider the contact theory, or that of Volta, in which the contact of dissimilar metals is supposed to be the seat of the E.M.F., and the chemical theory, in which chemical action alone is said to be the acting force. At first sight it appears strange that two such entirely different theories should survive; but the intrinsic difficulty of experiment is so great, that it is very hard to find a test which shall decide between the two.

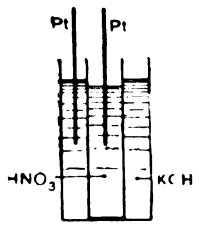


Fig. 2.—Becquerel's Cell.

In studying the phenomena which Galvani observed with his frogs, Volta found that the same convulsive movement could be obtained by the contact of two dissimilar metals, and he consequently referred the action to the junction of the two metals. This led him to construct his well-known pile, consisting of Zn, Cu and wet cloth. He also found that he could arrange the metals in a series, such that any one of them assumed a positive potential when in contact with a metal lower in the series; and that the potential difference, resulting from any number of metals connected together in series, is the sum of the differences due to the several contacts, and is also equal to that between the extreme metals. From this it follows that there can be no resultant E.M.F. in a closed ring of dissimilar metals, provided the junctions are all at the same temperature.

The contact force of dissimilar metals has been measured by a large number of physicists, generally by means of a condenser, the plates of which are made of the metals in question. These are placed parallel to each other at a small distance apart, and simultaneously touched with a wire of the same metal as one of the plates. The capacity is then diminished by separating the plates, and the deflection on an electrometer connected to one of them is a measure of the force. This is briefly the method employed by Kohlrausch.

The force of contact between metals and liquids has also been measured; but all these experiments must be received with a certain amount of caution, for the simple reason that we are uncertain as to what is really measured. No proof has been given of the existence, or non-existence, of force of contact between air and metals, or air and liquids. Such investigations, therefore, involve an unknown quantity which may vitiate all the results obtained.

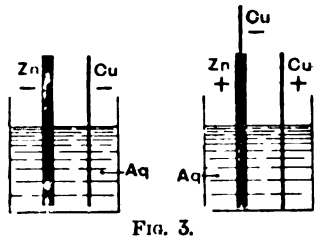


Fig. 3.

Lord Kelvin has given an elegant proof of the force of contact between dissimilar metals. A needle of thin sheet metal is suspended just above a circular plate made half of zinc and half of copper, so that it forms a radius to the plate, and lies initially in the direction of the diameter formed by the junction of the two metals. If the needle is charged positively it deflects towards the copper, the deflection being reversed if it is charged negatively, thus showing that there must be an E.M.F. of contact, the zinc being positive to the copper.

Nevertheless, these forces of contact do not appear to be as definite as could be desired. The results depend, to some extent, upon the nature of the surfaces employed. The theory is still less satisfactory when we consider the contact forces of liquids, or of liquids and metals. These cannot in general obey Volta's law, or there would be no E.M.F. in the ordinary cell. They have been measured in some cases, but they do not form a consistent series with the metals.

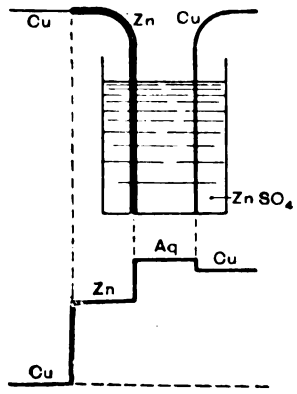


Fig. 4.—Potential Difference Diagram for Simple $ZnSO_4$ Cell.

In the simplest form of galvanic cell we have three contact forces to consider. Those due to either metal and the electrolyte may or may not cancel. For example,* if zinc and copper are immersed in water they are reduced to the same potential, and both are negative to the water (*see* Fig. 3). If, now, a piece of copper is attached to the zinc, the former becomes negative, while both the zinc and the immersed copper become positive, being maintained at the same potential by the water. The E.M.F. is simply that due to the Zn and Cu, the remaining contact forces cancelling.

But if $ZnSO_4$ is employed instead of the water this is not so. Here the

E.M.F.	$Cu - ZnSO_4$	$= -0{\cdot}113$ volt
,,	$ZnSO_4 - Zn$	$= +0{\cdot}358$
or electrolytic contact forces		$= +0{\cdot}245$
If that of $Zn - Cu = 0{\cdot}75$, then E.M.F. of cell		$= 0{\cdot}995$

* Fleeming Jenkin, "Electricity and Magnetism."

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Hence it is erroneous to suppose that the E.M.F. of a galvanic cell is given simply by the contact force of Zn – Cu. A potential difference diagram may be constructed as shown in Fig. 4, which is reproduced.

Volta's theory does not appear to have been strongly opposed until about 1830, when Faraday conducted a large number of experiments to test its correctness. He came to the conclusion that chemical action (decomposition as well as combination) is essential to a galvanic cell, and enunciated the law which bears his name, viz.: The decomposition which occurs in electrolysis, or in a galvanic cell, is perfectly definite, and is a measure of the total quantity of electricity passing round the circuit. He was thus led to think that the current was due simply to chemical action. It appeared unreasonable that the E.M.F.s of contact in a metallic circuit should be so balanced as to give no resultant, whatever the arrangement; and that electrolytes should either exert no contact force, or, if they do, that they should not be subject to the same law as the metals. It was found that no current was obtained if an electrolyte were employed, having no chemical action on either metal, even though in itself a comparatively good conductor; and Faraday, therefore, concluded that a current cannot be due to E.M.F. of contact. But we now know that no current could have been obtained under these circumstances without violating the law of conservation of energy: no energy is supplied to the circuit, and therefore none can be obtained from it. This test, therefore, fails to prove the point.

The truth in this case probably lies between the two theories. As Fleeming Jenkin observes: "The opponents of contact electricity denied and falsely explained things now known to be true, and the original supporters of the contact theory were ignorant of dynamics. . . . Perhaps it is accurate to say that the potential difference is produced by contact, and the current maintained by chemical action." Be this as it may, much remains to be proved.

Let us now turn from this somewhat unsatisfactory part of the subject to the consideration of two defects which soon became apparent in the voltaic cell, viz., local action and polarisation.

Local Action.

Local action, or loss through voltaic circuits on the positive plate, received no check until Sturgeon introduced, in 1830, the remedy of amalgamation which has not been superseded. The mercury is often said to act mechanically rather than chemically, the protection being afforded by a film of hydrogen which prevents the liquid from coming in close contact with the amalgam. Thus amalgamated zinc is unacted upon by dilute H_2SO_4, but, if a little HNO_3 is added, the hydrogen is removed by oxidation, and the zinc dissolves. This, however, is no proof of the assertion. The HNO_3 simply forms a voltaic cell in the manner hereafter considered.

It is a curious fact that the zinc has its properties but slightly changed by amalgamation. It is found that if amalgamated zinc and mercury are employed for the metallic elements, as in a Clark cell, the E.M.F. is practically unchanged, whether the percentage be large or small of mercury in the amalgam. In the case of the Daniell cell the E.M.F. is sometimes stated to be increased through the amalgamation by 0·13 volt.

Unfortunately, this remedy for local action cannot be applied to other metals. We are, therefore, restricted to the use of zinc for the positive plate, at least for acid batteries.

(*To be continued.*)

LAMP-HOLDERS.

The carbon glow lamp had not been invented many months before a holder was found to be necessary. It was natural that Edison should have been the first to design and to patent such an arrangement, for from the beginning, long before a practicable lamp had been discovered, he was arranging for mains, meters, switches, and a score of details by which electric light might be introduced into daily life. In his patent No. 578, of 1880, to which we shall refer again, he says: "As a necessary part of any practical system of electric lighting for domestic uses it is essential that the electric lamp should be simple in construction and complete within itself, requiring no skill in placing in position or in manipulating it. . . . A cup-shaped holder is made of insulating material, ornamented as desired, the bottom being fashioned so as to be secured in any suitable support, such as a bracket or chandelier. . . . The main conductors may pass to the holder through ordinary gas or other tubing, and through the bracket or chandelier arm or in any other suitable way." It was reasonable to guess at this early date that lamp-holders would be ornamented, but up to the present day this is almost unheard of, in spite of the ugliness of most patterns.

The lamp-holder question begins to acquire a new importance at the present time, since several lamp-holder patents still remain in force, and the more important of them are the property of the Edison and Swan United Electric Lighting Company. It is well known that this Company makes lamp-holders, and at the same time grants licences to other manufacturers. The terms of these licences it is beyond our province to discuss; suffice it to say that a considerable number of lamp-holders are made by the licencees, who thus compete with the proprietors of the patents. The patents under which licences are granted are the following:—

Edison, No. 578, February 10, 1880,	expiring	February, 10, 1894.
Swan, No. 5,702, December 28, 1881,	„	December 28, 1895.
Johnson, No. 1,094, March 7, 1882,	„	March, 7, 1896.
Dornfeld, No. 2,285*, January 28, 1884,	„	January 28, 1898.

Besides these patents we may allude to a few other early lamp-holder patents which are not included under the ordinary licence. These are:—J. W. and C. Swan, No. 4,390, 1882; A. Swan, Nos. 2,528, 1883; 5,153, 1883; 6,319, 1884; 9,185, 1884; 15,025, 1884; H. Pieper, 4,854, 1885.

Edison's patent, No. 578, 1880, for "Improvement in electric lamps, and in the method of manufacturing the same," contains 17 claims. The majority of these relate to the manufacture of the lamps; some of them are singularly wide. For example: the seventh claims "An incandescent conductor formed of a single carbonised fibre substantially as described." The claims relating to the subject at present under consideration are the ninth to the seventeenth inclusive, which are as follows:—

Ninth.—A separate electric lamp, adapted to be readily removed from or placed or replaced upon or within a suitable holder, substantially as herein described.

Tenth.—The combination of a separate removable electric lamp and a suitable holder, substantially as herein described.

Eleventh.—The combination of a separate removable lamp, a suitable holder, and electric conductors, which complete the circuit when desired to said lamp, but are not attached thereto, substantially as herein described.

Twelfth.—An electric lamp, consisting of a glass globe, substantially of one piece of glass hermetically sealed, and enclosing in a vacuum material capable of being rendered incandescent by an electric current, and provided at its base with contact pieces, substantially as herein described.

Thirteenth.—The combination in an electric lamp of a glass globe enclosing in a vacuum material capable of being rendered incandescent by an electric current, an insulated base, spring contacts, and conductors therefrom to the incandescent material substantially as herein described.

Fourteenth.—A socket or holder for electric lamps consisting of an insulating cylinder, formed to receive and support the lamp, and provided with two contact plates and a circuit controling device for controling the circuit to one of the contact plates, substantially as herein set forth.

Fifteenth.—The combination with a bracket or chandelier arm of a socket or holder adapted to receive and support an electric lamp, substantially as herein set forth.

Sixteenth.—The combination of a holder, bracket or chandelier arm with a socket or holder adapted to be received thereon, and to receive and support an electric lamp and conductors passing through the arm to contact plates in the holder, substantially as herein set forth.

Seventeenth.—The combination with a socket or holder provided with suitable contact plates of a lamp provided with corresponding contact springs upon its exterior, substantially as herein set forth.

The specification is illustrated by 13 figures.

The ninth, tenth and eleventh claims with their curious legal redundances contain the gist of this master patent. The licencees who work under this patent, and who, we presume, have thus acknowledged its validity, concede to Edison the grand invention not only of a lamp-holder, but of all lamp-holders.

If it may have seemed that we have ever failed to appreciate Edison's scientific work, we are ready to acknowledge, in cases of which this is an example, his marvellous foresight and

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shrewdness, it may be said that anybody who believed in the possible future of lighting by glow lamps would naturally have conceived the idea of a lamp-holder and a detachable lamp, but as a matter of fact Edison seems to have been the first to have formed this conception, and looked forward with all the confident visualisation which has characterised his work to a "practical system of electric lighting for domestic uses."

Contact pieces provided in the base of the lamp are alluded to in the twelfth claim, and in the thirteenth it is suggested that the base should be insulated, and that the contacts should be "spring contacts." The fourteenth claim, relating to the holder or socket, speaks of contact plates, and suggests the use of a switch. The seventeenth claim also suggests that the holder should be provided with rigid plates, while contact springs should be provided on the exterior of the lamp; these are shown in Fig. 12, which we reproduce. These claims for metallic contacts on an insulated base of a lamp, seem to be of considerable importance.

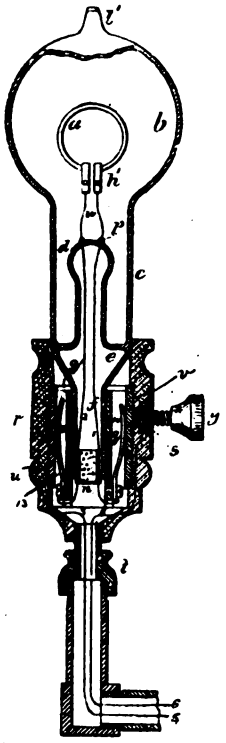
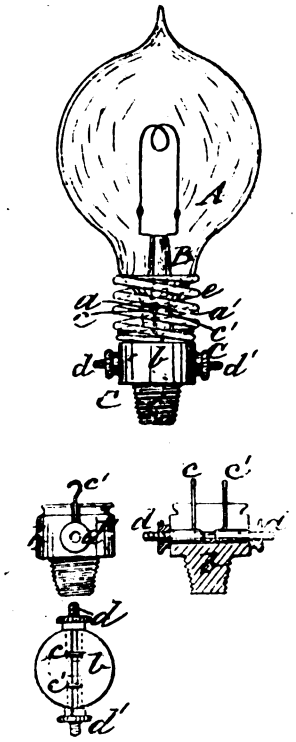


Fig. 12.
Reproduced from Edison's Specification No. 578, 1880.



Figs. 1 and 2.
Reproduced from Swan's Specification No. 5702, 1881.

Mr. J. W. Swan's first patent, 5,702, 1881, the second one of the licence, is a step backwards. We find described in the most minute detail the lamp with platinum loops and a holder with hooks. The specification begins thus :—

"My invention relates to improvements in sockets or holders for electric lamps, whereby a lamp without any external fittings can be readily attached to the conducting wire, and a good contact between them and the terminal hooks or eyes of the lamps can be effected and maintained."

Nothing could be more distinct from Edison's proposal to attach springs, and other metallic parts, to the base of his lamp than these simple contrivances of Mr. Swan, which are still to be found in some old-fashioned examples of electric lighting at the present day. In the course of his specification he suggests concentric contacts, and a system of concentric wiring is described. The system of rigid hooks and a spiral spring, as well as spring hooks is described. With the exception of the one provided with concentric wiring, the lamp-holders described in this specification are made with outside terminals. The following is his first claim.

First.—The employment of sockets or holders adapted to incandescent electric lamps without external fittings, and so arranged that efficient electrical contact is made aud maintained between the hooks or their equivalents of the socket or holder and the lamp terminals by the outward push of a spring interposed between the lamp and the lamp socket or holder, or by the act of screwing or sliding towards the lamp an external tube substantially, as hereinbefore described.

The second claim relates to details.

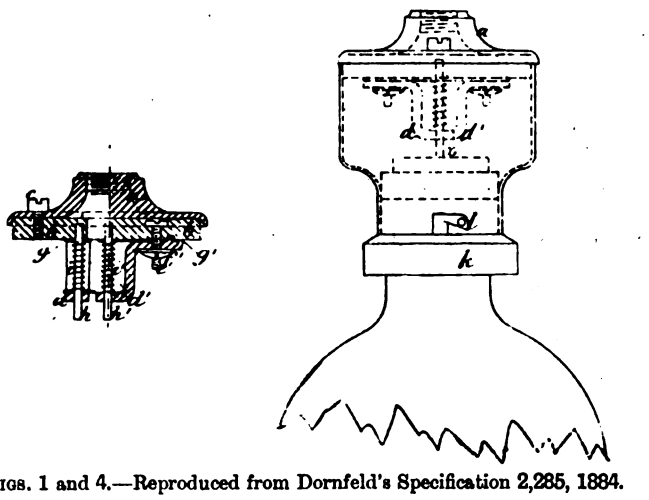
The fourth patent is that of Mr. E. H. Johnson, No. 1,094, 1882. The inventor is described as of Holborn-viaduct, in the City of London. The specification is very short, and contains only two claims. It very clearly describes the well-known Edison socket, with the coarse taper screw of thin metal, closely resembling the Edison socket which is in common use to-day. We understand that this socket was the invention of Edison, although his name does not appear in the specification.

After an interval of nearly two years, during which time no doubt many improvements were made in lamp-holders, Carl Dornfeld filed his patent, No. 2,285, 1884, for "Improvements in Holders for Incandescent Electric Lamps." Although a complete and very efficient lamp-holder is described in this specification, the pith of the patent is for "an arrangement of spring pins with guides." A lamp-holder with two large spiral or volute springs placed concentrically is illustrated and described, but the spring pins form the essential feature of the patent. The original specification contains four claims; the first two are as follows:—

First.—In holders for incandescent electric lamps the arrangement of spring pins with guides, which effect both the electrical contact with the lamp, and, by means of their vertical pressure against the lamp head, the secure fastening of the lamp in the holder, substantially as described with reference to Figs. 1 and 4 of the drawings.

Second.—The special arrangement of a holder for incandescent electric lamps with metal plate, insulating disc, guides, spring pins and metal casing, substantially as described with reference to Figs. 1, 2, and 4 of the drawings.

The third claim is for a modification, and the fourth claim, which was cancelled by amendment on February 6, 1890, related to the use of an insulating head-piece, an incandescent



Figs. 1 and 4.—Reproduced from Dornfeld's Specification 2,285, 1884.

electric lamp having on its circumference two diametrically opposite studs, and on its flat surface two small metal plates insulated from each other in connection with the wires from the carbon filament. We do not presume to explain the reasons for which this amendment was made, but it is clear that the metal plates which Edison proposed to affix to the sides of the stem of his lamp were substantially equivalent to the metal plates claimed by Dornfeld.

With the slight modification of mounting the spring contacts in tubes, forming the well-known buffer contact to be found in modern lamp-holders, this patent contains all the essentials of this extremely convenient and indeed indispensable device. In the body of the specification the lamp-holder is described as consisting of a disc of insulating material upon which are fixed a pair of Z brackets. The illustrations, however, two of which we reproduce, show a pair of small metal plates bent at right angles.

(To be concluded.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

WEDNESDAY, October 18th.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Dr. R. L. Maddox: "Remarks on Some Progressive Phases of Spirillum Volutans." Mr. F. Chapman: "Foraminifera of the Gault of Folkestone."

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The Electrician.

(The Oldest Electrical Journal.)

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.

Editorial, Publishing, and Printing Offices :

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.

Telephone No. 2714. Telegrams : "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "Coutts and Co."

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MODERN VIEWS OF ELECTRICITY.

The concluding portion of Prof. POYNTING's examination of Dr. OLIVER LODGE's electromagnetic hypothesis, which we print this week, is perhaps the most interesting, as well as the most original, of the three into which it has been divided. In a critical examination, originality is not to be looked for, but from a good criticism it is rarely absent. Cautious as are the leaders in Physical Science in giving their vaguer speculations, as Prof. POYNTING has told us, fearing that their weaker followers will distort their views; still more reluctant, perhaps, are they to examine in so careful a manner as Prof. POYNTING has done, the general hypotheses of any one man, although they will readily discuss separate parts of his work. A great debt of gratitude is owed not only by scientific men, but by the intelligent public to Dr. OLIVER LODGE for his "Modern Views of Electricity." Nobody else has ventured to collect hypotheses of the nature of electromagnetic science and to add to what has been drawn from others, a wealth of original speculation, but more than this, Dr. LODGE has been able for the most part to divest the subject of many of the difficulties which surround it, and avoiding mathematical language where most men would have no other treatment to offer, he has succeeded almost in removing even the appearance of abstruseness. But in reality his book is, as Prof. POYNTING has observed, by no means the easy reading which the absence of mathematical treatment might lead us to expect. Dr. LODGE has recently remarked upon the evils of being too explicit, and observed that the beauty of mathematics is that it is so vague; with what admirable care, then, has he rejected the easy method of ambiguity and has confined himself to simple English

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"The method which has been for the most part employed in conducting such inquiries," said MAXWELL at a lecture before the Chemical Society, "is that of forming an hypothesis, and calculating what would happen if the hypothesis were true. If these results agree with the actual phenomena, the hypothesis is said to be verified, so long, at least, as some one else does not invent another hypothesis which agrees still better with the phenomena. The reason why so many of our physical theories have been built up by the method of hypothesis is that the speculators have not been provided with methods and terms sufficiently general to express the results of their induction in its early stages. They were thus compelled either to leave their ideas vague and, therefore, useless, or to present them in a form, the details of which could be supplied only by the illegitimate use of the imagination. In the meantime the mathematicians, guided by that instinct which teaches them to store up for others the irrepressible secretions of their own minds, had developed with the utmost generality the dynamical theory of a material system."

Hypothesis, then, is a kind of imaginative garment with which we clothe our ideas. MAXWELL does not tell us on what grounds one hypothesis may be said to agree better with the phenomena than another, but of two hypotheses, both of which exhibit an equal agreement, that one is to be preferred which is the more simple; and when by successive additions to observed phenomena, an old hypothesis has to be patched and trimmed, and, to retain the metaphor, to be let out, to fit the whole body of facts, it is worth considering whether a new coat should not be made, and of more modern material. On the other hand, of two equally simple hypotheses that is the preferable which includes a rational explanation of the greatest number of phenomena; or, to be more exact, which gains the highest number of marks when to each phenomena which it explains there is attached a suitable figure indicating its importance. Simplicity alone, however, is not by any means the chief merit of a hypothesis. The well-worn hydraulic analogue is an example. Invaluable in the law courts and amply accurate for popular science in magazines, it presents ideas in a form, the details of which are supplied by an illegitimate use of the imagination. It is well that mathematicians should continue to store up the secretions of their minds well in advance of busy experimenters and speculators, who, when the one have got together a sufficient number of phenomena and the other a brood of larval hypotheses, may turn to mathematicians for nutriment, which will result in the production of a well developed theory.

So long as we were content with a solid elastic ether with a rigidity of 842·8 and a density of $9{\cdot}36 \times 10^{-19}$, as described by MAXWELL in the "Encyclopædia Britannica," the connection between electromagnetic and optical phenomena promised to become clearer year by year; and some of those who neglected to follow the various modifications which had been found necessary were disappointed to find that HERTZ'S researches had not settled the whole matter, and bound up the sciences of electricity and optics into one coherent unity. While the hypothesis of ether has become more and more intricate, the comparatively simple mechanical illustration of MAXWELL'S wheels and idle wheels has, in the hands of Dr. LODGE, been developed into a system of considerable complexity, and so far from being complete his hypothesis of the nature of electricity is only offered as the starting point of a hypothesis of magnetism—"Magnetism is nothing more or less than a whirl of electricity." Commenting on this, Prof. POYNTING turns to the Amperian hypothesis of magnetic molecules which owe their magnetic properties to a small closed electric current, and so many difficulties arise when criticised from a modern standpoint, that, useful as it has been in the past, many of our readers will feel that they can scarcely content themselves with suspending judgment on it, and remaining, as Prof. POYNTING confesses he must, in this state of suspense. We can part as Prof. POYNTING asks us from "perfect" conductors without a pang, and bid adieu to the Amperian molecule, and wish that physicists would, as he suggests, deal with matter as it is and not as we should have it if we had been consulted as to how it should have been made in order to simplify our equations. But we must not forget that while, on the one hand we sacrifice ideal matter in order to develope the fulness of our mathematical truth, we are equally called upon on the other hand to seek to devise some consistent material explanation in order to convert the mathematical expression to which we are led, into a physical truth. While he almost apologises for his criticism of Dr. LODGE'S views on the ground that he has nothing constructive to put in the place of the hypothesis to which he objects, Prof. POYNTING, in his last paragraph, suggests that progress is likely to be made by leaving ether out of account for the present, and by considering the electric and magnetic relations of molecules as those of large masses.

In a leading article on November 21, 1890, commenting on a communication from Dr. OLIVER LODGE on the transfer of energy by the ether, we protested against the doctrine of materiality of electricity. "There are only two things going," we quoted from Mr. OLIVER HEAVISIDE: "Matter and Energy; nothing else is a thing at all; all the rest are Moonshine, considered as Things." Electricity, we pleaded, is but the name for an agent which appears to underlie a certain group of phenomena, just as caloric was a very useful name, and was used to connote a similar agent which was supposed to appear and disappear by transference from one body to another. In another leading article on December 18, 1891, after objecting to the coulomb as an ancient residuum of the fluid theories of electricity, we suggested that it is more easy to conceive that a molecule is a minute magnet than to contemplate the Amperian hypothesis that magnetism is due to the circulation of molecular electric currents, and that if it be granted that every molecule is a magnet it is only necessary to move it in order to produce both electromagnetic and electrostatic phenomena. Why, then, we asked, do we need the idea of something called electricity, and that lumps of it should be measured in coulombs? We hope that the simple mode of thought which Prof. POYNTING recommends, may, by ignoring for the time an artificial structure of an unknown medium, lead not only to a rational understanding of electromagnetism, but to the solution of the profound problem of the structure of ether.

THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Continued from page 612.)

The author has adhered to the expression "watts per candle-power" in preference to that of "candles per watt," as, although the latter is the more correct, the former has the advantage of being the one generally adopted, doubtless because it is more convenient. It is easier to quickly grasp the meaning of a certain number of watts, and perhaps a fraction added, than of a particular fraction of a candle-power.

It will be readily understood from what has already been said that no lamp can be said to be *of* or to *have* a greater or

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less efficiency than another. One lamp may be run at a greater efficiency than another, and may then be said to be *at* a greater efficiency, but it possesses in itself no greater efficiency, as the other lamp can be equally well run at the higher efficiency.

The higher state of efficiency simply means that the filament is at a higher temperature. Any lamp may be run at any efficiency or temperature up to its breaking point. With incandescent carbon a certain temperature means a certain colour of light and a definite efficiency, either in watts per candle-power or in proportion of luminous radiation to total radiation. Whether the same thing can be said of all incandescent substances does not yet appear to be definitely settled. Certain of the metallic oxides may, perhaps, prove exceptions. The well-known Welsbach gas burner seems to suggest such an exception, but the author does not know of any tests upon this point. Certainly, to the unaided eye, the colour of the light of a Welsbach mantle is absolutely different from that of a gas flame, though the temperature of the particles of carbon in a gas flame might be supposed to be much the same as that of the Welsbach mantle. Certainly neither can be hotter than the gas flame. Possibly, however, the particles of carbon are very far below the temperature of the flame. These particles of carbon certainly have a very great emissivity, and they may, perhaps, radiate heat and light so fast that they never approach the actual temperature produced by the combustion of the gas. On the other hand, the Welsbach mantle, having a vastly inferior emissivity, is raised nearly to the actual temperature of the flame. The emissivity of the Welsbach mantle is extremely low. One which the author measured gave less than eight candles per square inch of surface when new. The carbon in a gas flame gives many times this amount of light per square inch. Accurate tests with a spectro-photometer might settle this question. If the material of the Welsbach mantle is only at the same temperature as the carbon particles in a gas flame, then it must have the property of selective radiation, and may, therefore, be found to have a greater light-giving efficiency than carbon.

In the case of using such oxides as the light-giving portion in electric lamps, one thing is apparent: it is that the extent of radiating surface will have to be very much greater than that of a carbon filament for the same amount of light if at the same temperature.

The only way to ascertain the relative superiority of different incandescent lamps is to run them all at a constant voltage and all at the same efficiency at the start. They must then be tested at periods of, say, fifty hours at the same voltage as the original test, in order to find the diminution in candle-power. Such tests might be called "deterioration" tests. Thus, a lamp which loses 10 per cent. in candle-power in 400 hours is a better lamp than one which loses that amount in 300 hours.

Life tests, pure and simple, are worthless. A great many carefully-ascertained life tests of different lamps have at various times been reported. Such tests are, however, of no value unless the actual tests of candle-power of the lamps at different periods of its life are also given. It is also equally necessary to know within what limits the difference of potential was maintained throughout the run.

All lamps fall off in candle-power when supplied with a constant number of watts. Lamps usually fall off in candle-power from the commencement of their active life, when supplied with current at a constant voltage. The deterioration in this case is, however, sometimes masked during the first hundred hours or so, by the resistance of the filament falling. A greater amount of power is therefore supplied to the lamp, which may, in consequence, give even more light after a hundred hours than it did at the first. Such behaviour is, however, the exception rather than the rule, and seldom occurs in flashed lamps.

What amount of deterioration should be allowed before a lamp is cast aside it is difficult to say. It depends upon the circumstances of each individual case. As long as a lamp gives sufficient light in its particular situation there is no need to change it. A new lamp may be fixed over a writing table, and after a hundred hours may be found to be no longer bright enough, it is therefore taken down, but it will do perfectly well in some other situation, say in a bedroom or passage for a further and longer period. The price of the lamp determines as much as anything the period at which it is thrown away. The cost of a candle-power hour for the actual amount of light given increases as the light of the lamp diminishes. In order that the total cost of maintaining a given amount of light may be a minimum, it is necessary to renew the lamps at certain definite times. The length of time each lamp is used depends in such case upon the price of the lamp, the price of the power, and the rate of deterioration of the lamp. As the last of these conditions is variable even with lamps of the same make, it is impossible to fix the period under any conditions of price of lamps and power. Lamps in ordinary use cannot be tested every fifty hours, and it therefore happens that they remain in use as long as they give light enough.

The length of time taken by lamps of the same make to deteriorate in candle-power by a certain percentage depends very much on their treatment. If the pressure is maintained constant, say within 2 per cent. on either side of the normal, the useful life will be longer than if the pressure is allowed to vary much. The pressure at which electricity is supplied by central stations is anything but constant. The very best supplies are not to be relied upon to keep within 5 per cent. on either side of the normal, while some extensive supply systems do not keep within 10 per cent. The alternating systems seem to be more difficult to regulate than the direct-current ones. Deterioration tests of lamps of the same make on the different supply systems would be very interesting and instructive, and would go far towards settling the dispute as to the relative merits of the various systems in use.

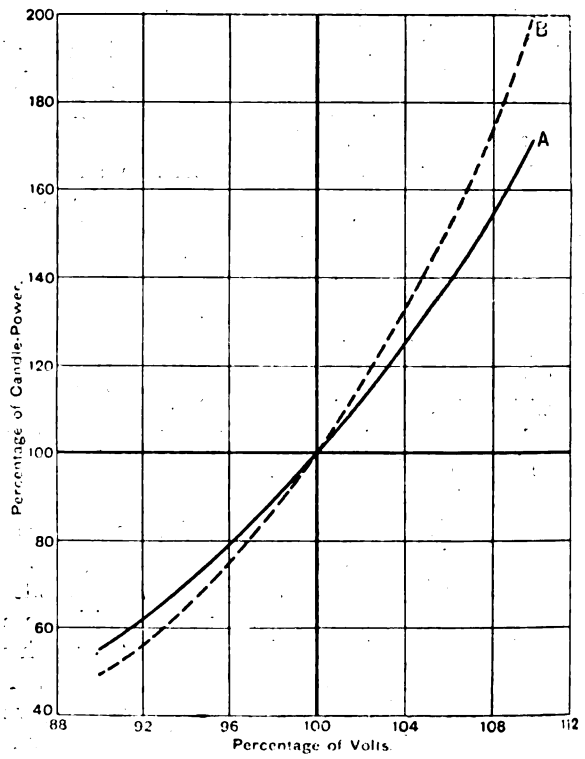

FIG. 40.

In order to show the importance of the constancy of the pressure, Fig. 40 is given. It shows approximately the percentage variation in candle-power for any given percentage variation in the volts over a range of 10 per cent. above and below the normal. It will be found to be about correct whatever be the temperature or efficiency of the lamp at normal voltage. The curve A gives the results when the filament is constant in resistance over the range of 10 per cent in volts. The dotted curve B gives the result if the filament uniformly falls off in resistance by 5 per cent. for an increase of 10 per cent. in the volts. As a rule the values lie nearer B than A. It will be seen that a slight increase in the pressure causes

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the candle-power to rise greatly, while a slight decrease means a poor light.

The falling off in the candle-power of lamps is due to particles of carbon being thrown off the filaments. This action reduces the light of the lamp in three ways. Firstly, the particles of carbon form a coating on the glass of the lamp, and, therefore, obscure the light given by the filament. Secondly, the nature of the surface of the filament is altered, and its emissivity is increased so that it is at a lower temperature. Thirdly, the resistance of the filament is increased, so that it takes less current, and is again on this account at a still lower temperature. Thus, not only does the filament give less light, but a great proportion of what it does give is prevented from getting outside the bulb. In order to find out what proportion of the total loss of candle-power might be due to these different causes the author made the following somewhat extreme test.

A lamp was tested at about 2 watts per candle-power. It took 51·7 volts and gave 55 candle-power for a consumption of 107·7 watts. It was then run at that voltage until it was much blackened. It was then tested again. At 51·7 volts it gave only 12 candles, and, owing to rise in resistance, it took only 100 watts. The total loss of candle-power was therefore $55 - 12 = 43$, or 78 per cent. In order to find out how this loss was made up, the filament was taken out of the blackened bulb and put into a new one. The air was then exhausted to the same degree as before, showing a very good vacuum by the spark test. The lamp was then again tested. At 51·7 volts it took 100 watts, and gave 30 candles. It was then run a little brighter so as to take the original power of 107·7 watts, and it gave 42 candles and took 52·8 volts. The loss of light due to the blackened bulb was therefore $30 - 12 = 18$ candles $= 60$ per cent.

The loss due to increase in emissivity is given by the decrease in candle-power, when the same amount of power was supplied to the filament. The loss due to change in emissivity is therefore $55 - 42 = 13$ candles $= 23{\cdot}6$ per cent.

The loss due to change in resistance is given by the difference in candle-power when the filament was supplied with the original number of watts, and when supplied with the original number of volts; because, had the resistance not gone up, the original number of volts would have given also the original number of watts. The loss due to increased resistance is therefore $42 - 30 = 12$ candles in $55 = 21{\cdot}8$ per cent. The rise in resistance is about 8 per cent. The loss due to change in emissivity plus that due to change in resistance, therefore $= 13 + 12 = 25$ candles $= 45{\cdot}5$ per cent.

This result is also shown by the difference between the original candle-power and that at the original volts when the filament is in the new bulb, *i.e.*, $55 - 30 = 25$ candles. It is therefore apparent that the filament at the original volts gives 25 c.p. less than it gave at first. It gives only 30 candles, or 54·5 per cent. of its original candle-power.

We have already seen that the blackened glass obstructs 60 per cent. of the light of the filament; therefore, of this 54·5 per cent. of light given by the filament, 60 per cent. is stopped by the blackened bulb.

60 per cent. of 54·5 per cent. $= 32{\cdot}6$ per cent. The total reduction in the light of the lamp is therefore made up in the following way:—

Less light given by filament, owing to	Candles.	Per cent.
(1) Increase in emissivity	13	23·6
(2) ,, resistance	12	21·8
Total (1) and (2)	25	45·4
(3) Stopped by blackened glass	18	32·6
Total reduction	43	78·0

The greater part of the decrease in the light of the lamp is therefore, due to the fact that the filament gives less light. Of the light which it does give only a part gets through the blackened bulb.

Though the above test may be considered an extreme one, the lamp having been very much overrun, the same kind of result undoubtedly occurs in lamps run at ordinary temperatures.

The black deposit on the bulb of a lamp stops not only much of the light radiation, but also much of the heat. The result is that a blackened lamp gets hot. A much blackened lamp may often be found to be too hot to hold.

The effect of a fall in the resistance of a lamp is strikingly shown in the following test: An unflashed lamp had just been tested at 50 volts. It gave 12·5 candles, and took 0·82 ampere, and, therefore, 41 watts, and its resistance was 61 ohms. It was then accidentally run for an instant at 100 volts. The testing was being done on a 100-volt circuit, and the resistance in series with the lamp was momentarily short-circuited. The bulb was in consequence blackened, and the filament had lost its shiny appearance. It was therefore expected that a great diminution in candle-power would be observed at 50 volts. The resistance of the filament had, however, been so much reduced as to more than counteract the dulling effects. The lamp tested 50 volts, 1·03 ampere, 22 c.p., and, therefore, 51·5 watts and 48·5 ohms. The resistance had gone down 20 per cent., so that the lamp took so much more power than it did at the first that the increase in emissivity which undoubtedly occurred was not sufficient to prevent a great increase in the temperature of the filament; and the blackening of the bulb, though great, was also not sufficient to mask the effect of the great increase in the light given by the filament.

If a filament could be found whose resistance gradually fell as its emissivity increased and the bulb blackened, a lamp of uniform candle-power or of uniform watts per candle-power throughout its life might be possible. Such a lamp would not have so long a life as one of which the resistance increases, but it would have a more useful life, and would automatically end its career at the proper time. Unfortunately, the filaments which are usually found to fall in resistance do so during the first part of their life, when they should remain constant, and when they should be going down they increase.

(To be concluded.)

A POTENTIOMETER METHOD OF MEASURING THE ELECTROMOTIVE FORCE OF TRANSFORMERS.

BY BERNARD P. SCATTERGOOD.

Engineers who have had experience in making workshop tests of dynamos and transformers will know what difficulty there is in arriving at results which can lay claim to any degree of accuracy, when the engine which is the only available source of power has to drive a number of heavy machines in addition to the dynamo. Under such conditions it is impossible to secure anything like a constant dynamo speed; and with a primary voltage varying between perhaps 1,900 and 2,100 volts, or within even wider limits, it is not easy, to say the least of it, to read the secondary voltage of a transformer to within even 2 or 3 per cent. It was to overcome this difficulty that I originally designed the method to be shortly described, in the development of which some interesting results were arrived at. From certain analogies with Poggendorf's well-known test, I have called it a "potentiometer" method.

The method I adopted was to couple the secondary of the transformer whose open circuit E.M.F. was to be measured, in series with that of a standard transformer of which the secondary E.M.F. at the normal primary voltage (in this case 2,000) was accurately known. The primaries of the two transformers were connected in parallel on the high-tension mains, in such a way that their secondary electromotive forces were opposed; and in the secondary circuit was placed the thick coil of an auxiliary step-up transformer of known conversion ratio, across the fine wire coil of which was connected a Kelvin multicellular electrostatic voltmeter. The arrangement is shown in Fig. 1. Under these circumstances, the standard transformer and that

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under test both being unloaded, their secondary electromotive forces are in opposite phase to those in the respective primaries; and as the method of coupling up ensures that the primary voltages at the terminals of the two transformers are in opposite phase to each other, this is also the case with the secondaries. Hence, if the two secondary electromotive forces are exactly equal, they balance each other; no current flows in the circuit, and no deflection is seen on the voltmeter. But supposing them to be unequal, then there is a resultant E.M.F. in the circuit, namely, the difference between the two secondary electromotive forces; this being impressed as a potential difference at the terminals of the step-up transformer, is magnified by the fine wire coil in the ratio of the windings, and the deflection of the voltmeter needle thus becomes a measure of the difference between the E.M.F. of the standard and that of the transformer which is being tested. As the former is known the latter is thus at once arrived at.

The subject of the first experiments which I made to test the feasibility of the method was a 2-H.P. Lowrie-Hall transformer (No. 1,669), of which the secondary E.M.F., with 2,000 volts on the primary, had been carefully determined by several direct measurements, and found to be 102·15 volts. The secondary E.M.F. of the transformer used as the standard was, as nearly as could be measured, 100 volts; it was wound with 100 turns on the secondary, thus giving one volt per turn. In addition to the ordinary secondary winding, it had 10 extra turns wound upon it, in four sections of one, two, three, and four turns respectively, all or any of which could be connected in series with the main secondary coils, and in such a way as either to help or to oppose the latter. Thus the voltage at the terminals of the standard could be varied at will from 90 up to 110. The necessity for being able to adjust the standard voltage in this way will be clear from the consideration, that from a single voltmeter reading it is impossible to say whether

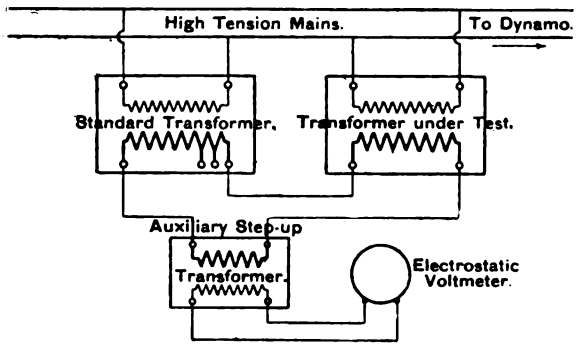

FIG. 1.

the actual E.M.F. of any transformer is greater or less than that of the standard. Thus, two transformers having open circuit electromotive forces of 103·28 and 96·72 volts respectively would each of them give the same resultant E.M.F of 3·28 volts, if that of the standard were 100; and the voltmeter deflection would be the same in the two cases. A second reading, however, with a different voltage on the standard, at once settles the matter. For example, the standard E.M.F. is raised, say, to 100 volts; then, if the deflection is increased, obviously the E.M.F. which is being measured must be less than 100; if the deflection is diminished, the E.M.F. must be greater than 100. The best way to make the adjustment of the standard voltage is by means of plugs similar to those of a P.O. box, by which a greater or lesser number of turns of secondary are put in circuit. The details of such an arrangement will readily suggest themselves; but, of course, it must not be done by short-circuiting the coils.

The auxiliary transformer used in the preliminary experiment was a 2-H.P. transformer of conversion ratio 1 to 20, and similar to that which was used as the subject of the test. The frequency of the alternations was about 120.

With the connections arranged as in Fig. 1 a series of readings was taken with different voltages on the standard, throughout the range of its adjustment. In the second column of Table I. will be found the observed voltmeter deflections; these are, as will be seen, very nearly proportional to the standard voltages at which they respectively occur. But before describing these results it will, perhaps, be better to briefly indicate those which theoretical considerations might lead us to expect.

If a series of readings, such as that above referred to, were to be plotted on squared paper, with standard voltages as abscissæ, and the corresponding voltmeter readings as ordinates, it will be seen that theoretically the curve should consist of two straight lines, equally inclined to the horizontal axis, and meeting at a point within it; and, further, that the shape of the V which forms the curve depends on the conversion ratio of the auxiliary transformer used, the tangent of the angle of inclination of the lines to the vertical axis being, in fact, numerically equal to this ratio, provided that the vertical and horizontal distances are plotted to the same scale. Evidently, too, the point on the horizontal axis on which the apex of the V rests is the point where the two electromotive forces, that of the standard and that of the transformer under test, balance

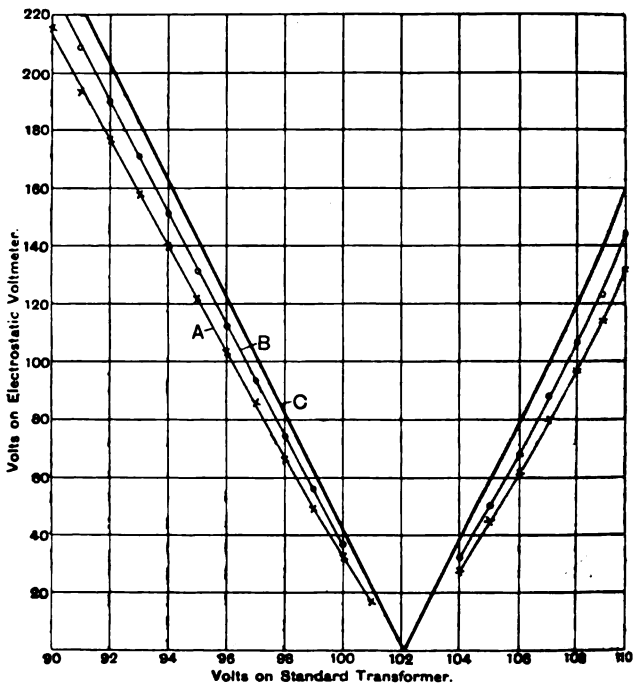

FIG. 2.—E.M.F. Curves (at No Load) of a 2-H.P. Lowrie-Hall Transformer (No. 1,669).

A, Auxiliary Four 2-H.P. Transformers in Parallel; B, Auxiliary Two 2-H.P. Transformers in Parallel; C, Theoretical Curve.

each other, and the E.M.F. of the latter can, therefore, be at once read off, being equal to the standard voltage at this point.

Now, if our observed readings are plotted in the manner indicated above, it will be seen that the sides of the V which form the curve are not quite so steep as they should theoretically be; in other words, the voltmeter deflections corresponding to the several standard voltages are all of them slightly less than they ought to be. This may be expressed by saying that the "virtual conversion ratio" of the auxiliary has a greater value than that indicated by the ratio of the windings. The sides of the V, too, are not perfectly straight lines, but bend slightly inwards towards each other near the bottom of the curve. This effect, though not very marked in the particular instance taken, becomes in some cases very noticeable.

So much for the discrepancies between theory and observation, with the causes of which I hope to deal more fully in a future Paper. At present it is sufficient to say that they arise from a drop in voltage, partly due to resistance in the circuit external to the auxiliary (I R drop), but chiefly to magnetic leakage. I shall show, however, that these disturbing elements can be entirely eliminated in practice. The important thing to be noticed just now is that the vertical axis of the V curve, plotted from the observed readings, cuts the horizontal line of standard voltages at what is known to be the voltage of the transformer, namely, 102·15 volts.

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It is obvious that any method of testing which necessitated 20 separate readings and the drawing of a curve in order to determine the secondary E.M.F. of a transformer would not be a practical one. Fortunately, however, this is not the case; but the practical application of the method to workshop testing I shall defer until I have described the experiment made in order to determine the influence which the nature of the auxiliary transformer used has upon the results obtained. For this purpose I arranged three additional 2 H.P. transformers, similar in all respects to the one previously used as the auxiliary, of which the secondary (thick) coils could be connected in parallel. The conversion ratio of each transformer was 1 to 20. Thus by using one pair of primary terminals only, or two, three, or four in series, the potential difference at the secondary terminals could be multiplied 20, 40, 60 or 80 times, as might be necessary. Four sets of readings were taken, the first (that which has been referred to above) with only one transformer as auxiliary; the others with respectively 2, 3, and 4 transformers with their secondaries in parallel. The results obtained are tabulated below, and two of the sets of readings are reproduced graphically in Fig. 2, in which the curves marked *a* and *b* correspond with the readings taken with four and with two auxiliary transformers respectively.

Table I.—*Showing observed Voltmeter Deflections at Different Standard Voltages, with one, two, three, and four Auxiliary Transformers (No. 1,669, no Load).*

Voltage of standard.	Voltmeter deflections.			
	Auxiliary, one transformer.	Auxiliary, two transformers. (Fig. 2, B.)	Auxiliary, three transformers.	Auxiliary, four transformers. (Fig. 2, A.)
90	237	230	223	216
91	217	209	203	194
92	195	190	183	177
93	174	171	163½	158
94	155	151	144	140
95	135	131	126	121½
96	116½	111½	107½	103½
97	98	92¾	89	85½
98	78½	74	71¼	66
99	59	55½	52	49½
100	...	37	35	32·6
101	...	...	...	16 6
102	...	...	..	...
103	...	...	...	...
104	...	31·5	29·2	27 2
105	...	49 5	46·4	43·8
106	72	68	64 1	60·6
107	91½	86½	82	77
108	110½	105½	101	95½
109	130	123	118½	114
110	150	143	138½	131

For the sake of clearness in the diagram the curves for one and three auxiliary transformers are not shown; but it will be seen from the table that, for the same standard voltage, the voltmeter deflections obtained with four, three, two and one transformer are practically in arithmetical progression. It is accordingly allowable to extend the series a step further, and by extrapolation to obtain a fifth set of figures which corresponds, so to say, to *no* auxiliary transformers; that is, to an auxiliary transformer of infinite impedance, representing the case where the whole E.M.F. in the circuit is impressed at the terminals of the auxiliary. This has been done, and the result is the curve marked C in the diagram ("theoretical curve"). It will be seen that this is actually the curve which we should expect to get after eliminating the disturbing causes alluded to above; the slope of the lines being such that the tangent of the angle of their inclination to the vertical axis is exactly equal to the conversion ratio (1 to 20) of the auxiliary transformer used; or rather, it would be equal to this ratio if horizontal and vertical distances were plotted to equal scales. In the actual diagrams, as will be seen, the vertical distances are to a scale ten times smaller than the horizontal.

Now let the deflections which constitute the right-hand branch of the curve be considered as negative, and plotted therefore below the horizontal line of zero deflection; the V-shaped curves of Fig. 2 then assume the form of nearly straight lines, as in Fig. 3, all of which cut the horizontal axis in one point, the balancing point. Hence it is plain that all disturbing effects are eliminated by simply taking two readings of the voltmeter on opposite sides of the balancing point, preferably adjusting the standard voltages so that these deflections are as

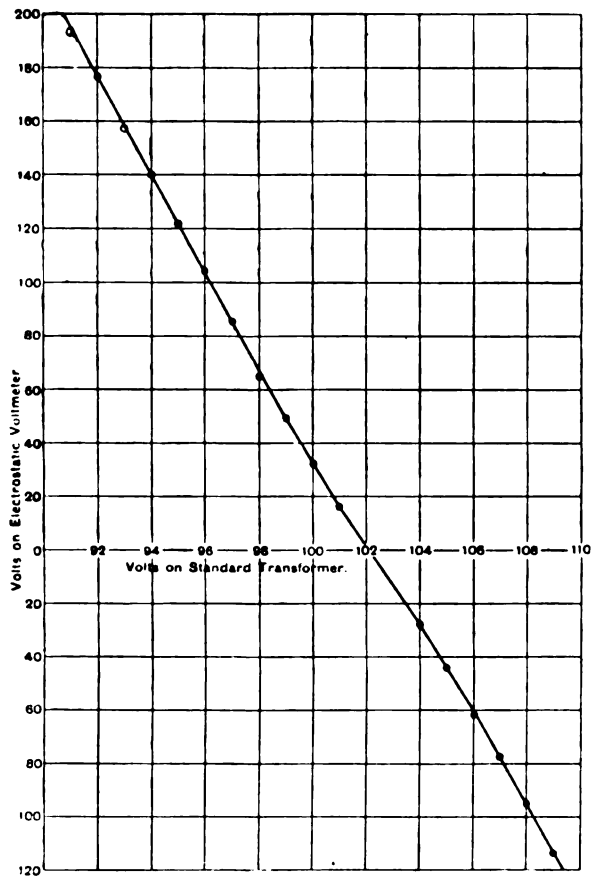

FIG. 3.

nearly as possible equal. The reason for this lies in the tendency above referred to, of the lines to become slightly convex to the horizontal axis as they approach it. By taking two nearly equal deflections on opposite sides of zero the effect of this deviation from straightness is eliminated.

(To be concluded.)

NOTES ON THE E.M.F. & TEMPERATURE COEFFICIENT OF THE CADMIUM MERCURY CELL.

BY ARTHUR DEARLOVE.

A type of this cell is patented by Mr. Weston, and it is suggested by him that it should be accepted as a standard of E.M.F. The cell, its form, and the method to be followed when setting it up, is described by him in his Patent No. 22,482, dated 1891. (Mr. Weston states in his patent that the E.M.F. of this combination is 1·019 true volts, and that its temperature coefficient is 0·01 per cent. per degree Centigrade.)

Briefly stated, the cell consists of electrodes of pure mercury and cadmium amalgam, with a saturated solution of cadmium sulphate and protosulphate of mercury. I mention here the fact that the latter salt should be in excess. Unless this is so I found the E.M.F. to be somewhat higher than that given below.

From the above remarks it will be seen that this cell differs from "Clark's standard cell" in that cadmium amalgam and cadmium sulphate solution is used in place of the pure zinc and zinc sulphate solution employed in Clark's standard of E.M.F.

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The following notes are merely a record of my endeavours to construct these cells satisfactorily, and to investigate their claim to be regarded as standards of E.M.F.

This experience may be of some value to those who, like myself, wish to set up the cells and have nothing to guide them but the instructions given in Mr. Weston's patent.

The first cells made were set up in June, 1892; the amalgam used was prepared by heating mercury and cadmium together in a crucible, adding cadmium, until specimens of the amalgam on cooling were found to be sufficiently rigid to retain the form of a rod. The exact proportion of the metals was not in this instance determined, but was approximately 5 parts of mercury to 1 part cadmium by weight.

The solution was prepared carefully, using distilled water and pure sulphate of cadmium. The saturated solution of Cd Sulph, when setting up the cells, was heated with the washed protosulphate of mercury, as is usually done with the zinc sulphate and protosulphate of Hg when making the Clark cell.

The complete cell is shown in Fig. 1.

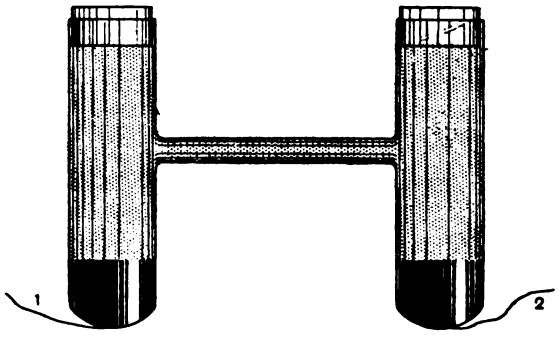

FIG. 1.—Cell containing Mercury in contact with Wire No. 1 and Cadmium Amalgam in contact with Wire No. 1. The rest of the cell is filled with a saturated solution of Cadmium Sulphate and Protosulphate of Mercury.

The following figures show the results obtained, the E.M.F. in T.V., and the temperature coefficient of the cells between the limits given :—

No. of cell.	June 1st, set up.	June 10th.	June 13th.	June 16th.
1	1·0398	1·034	1·0351	1·0354
2	1·0386	1·034	1·0348	1·0340
3	1·0373	1·036	1·0370	1·0365

The above figures are corrected for temperature by the values given below.

The temperature coefficient per degree Centigrade of these cells was found to be respectively as follows :—

Cell.	Between 0°C. and 15°C.	Between 15°C. and 27°C.	Between 27°C. and 43°C.
1	0·024 per cent.	0·05 per cent.	0·037 per cent.
2	0·0235 „	0·046 „	0·030 „
3	0·0205 „	No. 3 broken.	.....

Clark's standard cell and slides method was used for purposes of determination.

These figures showed no remarkable agreement, either as regards E.M.F. or temperature coefficient, with the values given by Mr. Weston, and some experiments were made with amalgams of different proportions of cadmium and mercury. The ratio of these two metals appears to have an important bearing on the resulting E.M.F. of the cell; this is clearly shown to be the case by the figures given in the subjoined table, where the E.M.F. of variable proportions of cadmium and mercury are given :—

	E.M.F. True Volts.
No. 1 cell. Cad-Amal, with large proportion of Hg	1·0377
„ 2 „ „ smaller „	1·0550
„ 3 cell, with pure cadmium amalgamated	1·0436
„ 4 „ „ electrode	1·0800

Another cell of H form was set up with 36 grammes of pure mercury in each leg and a saturated solution of Cd Sulph and Protosulph. Hg to one side of the cell, finely divided cadmium in definite proportions was then gradually added, the E.M.F. being taken after each addition of cadmium :—

	E.M.F. in T.V.	Remarks.
1st—Pure Hg V. Pure Hg.....	Nil	—
„ V. 1 Parts. Cd & 100 Parts. Hg..	1·00	Unsteady when shaken
„ 2 „ „ „	1·0065	„ „
„ 5 „ „ „	1·0139	„ „
„ 7 „ „ „	1·0164	„ „
„ 10 „ „ „	1·0168	Only slightly.
„ 14 „ „ „	1·0192	Steady when agitated.

It is evident from the above figures that the E.M.F. is a variable quantity dependent upon the amounts of cadmium and mercury with which the amalgam is formed.

Until the proportion of cadmium equals at least one-seventh by weight of the mercury, neither the E.M.F. or the temperature coefficient are near the values given by Mr. Weston.

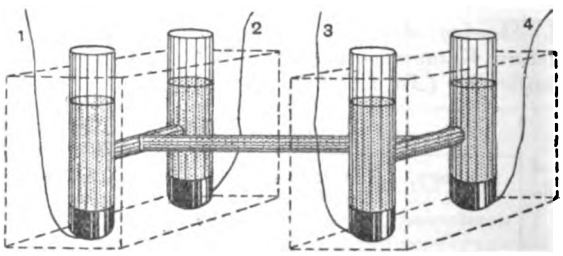

FIG. 2.—Cells containing Mercury in contact with Wires Nos. 1 and 3, and Cadmium Amalgam in contact with Nos. 2 and 4. The rest of the cell is filled with a saturated solution of Cadmium Sulphate and Protosulphate of Mercury. The dotted lines represent the outer vessel.

I noted also as a peculiarity of this cell that until the proportion of 7 Hg to 1 Cd is reached, that agitation or disturbance produced violent changes in the E.M.F. When this proportion is arrived at the cell remains practically steady and constant in E.M.F., though subjected to treatment which Clark's standard cell would not allow of without misbehaviour.

Having practically decided this point three other cells were made, one of the ordinary H form, and the others may be described as a double H cell. Each cell was enclosed in a separate vessel, the arrangement is represented by the Fig. No. 2. This mode of construction allowed of one cell being kept a constant temperature, whilst the temperature of the other was varied at will.

Four combinations were possible with this form, and I was able to determine which electrode was affected by change of temperature and caused the increase or decrease of E.M.F. The table following gives the results of tests made from time to time over a period of nearly a year :—

Value in True Volts uncorrected for Temperature Variations.

Cell.	June 25, 1892.	June 27, 1892.	July 26, 1892.	Oct. 13, 1892.	Apr. 28, 1893.	May 15, 1893.	May 30, 1893.
A } double H {	1·029	1·030	1·030	1·028	1·032	1·032	1·030
B } double H {	1·027	1·028	1·030	1·030	1·029	1·029	1·030
C	1·026	1·029	1·032	1·031	1·029	1·029	1·030
Temp. at time of obs.	17·5°C.	19·5°	18·5°	15·0°	15·6°	17·0°C.	15·7°C.

The behaviour of these cells has not been entirely satisfactory, but the results are not discouraging to the idea that a cell of this pattern can be made having an E.M.F. of a constant value, and, what is of considerable importance, a variation of E.M.F. on change of temperature, which between the limits of 0° and 20°C. is certainly not higher than 0·01 per cent. per degree, and may be as low as 0·003 per cent. per degree C.

The reason why the E.M.F. of these cells is higher than the 1·019 mentioned is that the amalgam was not of the 7 to 1 proportion; 10·8 grammes of cadmium were used with 58·3

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grammes of mercury; the temperature coefficient between 15° and 43°C. was 0·016 per cent. per degree.

It was found that practically the whole change of E.M.F. occurring on decrease or increase of temperature was due to the effect of such changes on the amalgam. The highest E.M.F. obtained was with cadmium amalgam at 0°C. and mercury at 19°C.; the lowest was noted with cadmium at 19° and mercury at 0°C.; in other words, the *lower* the temperature of the amalgam electrode the *higher* the E.M.F., and to a smaller extent the *higher* the temperature of the mercury the *higher* the E.M.F.

The work was now interrupted, but in May this year a number of cells were set up, the actual weights of Cd and Hg in the amalgam being 42½ and 281 grammes respectively, or a 1 to 7 proportion.

As before, Clark's standard cell and the slide method was used in all cases, the Clark cell being corrected for temperature variations.

The E.M.F. is given for these cells at the temperatures 15·5deg., 33·5deg., and 64deg.

No. of cell.	True volts 15·5 C.	33·5°C.	64°C.	Per deg. C. Temp. coeff. between 15·5°C.	
				33·5°.	64
1	1·0197	1·0185	1·0159	0·007%	0·008%
2	1·0196	1·0185	1·0146	0·006%	0·010%
3	1·0194	1·0189	1·0143	0·003%	0·010%
4	1·0189	1·0184	1·0142	0·003%	0·010%
5	1·0193	1·0186	1·0161	0·004%	0·007%

The temperature coefficients given are roughly calculated, and no explanation can be offered as to the difference in its value for the various cells, as they were all taken under exactly the same conditions and at the same time.

As these cells fell to normal temperature from 64°C., their E.M.F. was taken at three temperatures, viz., 40°C., 24°C. and 17°C. the thermometer was inserted into the cell itself and showed the temperature had fallen to these values, the E.M.F.'s, however, showed no appreciable change for some considerable time, and then exhibited comparatively a large amount of irregularity between themselves.

After subjecting these cells to these tests, they never quite regained their original value at the normal temperature, the E.M.F. remaining lower to an appreciable extent.

I regret that the following determination was not made before the one remarked upon above, as I consider the results may have been affected by their previous treatment.

The values obtained for the E.M.F. at 15·7deg. and at 0°C., with the tests showing their subsequent recovery, are tabulated below:—

No. of cell.	Temperature 15·7°.	At 0°C. after three hours' immersion in crushed ice.	Three days after this experiment.
1	1·0176	1·0178	1·0189
2	1·0178	1·0165	1·0184
3	1·0172	1·0160	1·0180
4	1·0167	1·0170	1·0178
5	1·0167	1·0167	1·0178

It will be seen that the temperature coefficient between 15·7°C. and 0°C. is very small and somewhat irregular; but for almost all practical measurements, the temperature correction may be neglected.

It was noted that the alteration of E.M.F. follows the change of temperature very slowly, and under the same conditions Clark's standard cell behaves in a similar way.

The above five cells have been tested from time to time since construction, and have satisfactorily maintained their original values.

Attempts to form these cells electrolytically, using a current of 0·25 and 0·5 amperes, were not successful. The salt of mercury thrown down by this process was yellow, and is known as "turpeth mineral." Their E.M.F. was higher than that when pure photosulphate is present.

Some cells have been set up by Dr. Muirhead under the conditions mentioned by myself. He has forwarded to me the following results, which may be considered entirely satisfactory.

The first six cells are made with 7 parts Hg to 1 cadmium by weight, and No. VII. has 6 parts Hg to 1 cadmium. The Board of Trade value of 1·4345 volts at 15°C. is taken for Clark's standard cell used.

No. of cell.	July 9, 1893.	July 12, 1893.	——
1	1·0190	1·0190	7 parts Hg to 1 Cd
2	1·0193	1·0190	" "
3	1·0190	1·0189	" "
4	1·0190	1·0189	" "
5	1·0189	1·0189	" "
6	1·0188	1·0188	" "
VII.	1·0196	1·0196	6 parts Hg to 1 Cd

The temporary coefficient of the above cells between 2·5°C. and 22°C. was found to be 0·008 per cent.

On September 20th last I witnessed the tests for E.M.F. of this batch of cells, and found that they had maintained with exactness the values given for the tests made on July 12, 1893.

General Conclusions.

1st. That a more lengthened experience with the Weston cell is necessary before speaking of it as a possible rival to Clark's standard of E.M.F., whose constancy under proper treatment is maintained for years.

2nd. The cell is set up with ease, and considerable accuracy is attained. One may say that proof is given in these notes that separate workers using different materials arrive at practically indentical results.

3rd. The cell submits to rough treatment and maintains its E.M.F. constant.

4th. That the low and almost negligible temperature coefficient of the cell, not amounting to $\frac{1}{10}$th that of the Clark cell, is an undoubted and important advantage.

The cell set up in the H form, as suggested by Mr. Weston, has the disadvantage of not being *portable*. Dr. Muirhead and myself have designed a cell which overcomes this difficulty.

The modifications we have introduced and adopted impair in no way the constancy or merits of the cell as regards its electrical behaviour.

In this *portable* type of a cadmium-mercury cell, as constructed by Dr. Muirhead, the cadmium amalgam electrode is either cast round a platinum spiral or pressed down tightly into a perforated glass tube; the free mercury electrode is replaced by an *amalgamated* and closely wound platinum spiral. The complete cell is then fitted in an outer case similar to that provided with the Clark's standard.

PRACTICAL MACHINE-SHOP INSTRUCTION IN TECHNICAL SCHOOLS.*

BY PROF. JOSEPH TORREY.

In any discussion of technical-school instruction it must be treated as an existing, and not an imminent, thing. It is out of the pioneer stage, and more or less independent of criticism. In fact, barring seniority, which is not a very lucrative possession, the technical schools have, all round, rather the best of the colleges. Anyone who studies their history in this country will be greatly impressed with the high ideals and broad wisdom of the men who were instrumental in evolving them, and yet, if he has been a careful student of human history, he will say to himself that institutions have not always been able to carry out the purposes of their founders, and he will naturally inquire how far the ideals of the founders are being realised in the modern technical schools.

In most modern systems of technical education the machine-shop holds a prominent place. What is its object? Is it intended to furnish a species of apprenticeship from which boys shall emerge machinists, or is it simply a laboratory, and amenable to the same limitations and laws as any other educational instrument?

At the very outset we shall find that the answers to the foregoing questions depend largely on what answers we give to another

* From the *Engineering Magazine*, October, 1893. (London: 1, 2 and 3, Salisbury-court, Fleet-street, E.C.)

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similar set, involving the aims and objects of those who attend these schools, and the results of the training they gain there as shown by their after experience. These questions we can answer in a general way quite readily. The greater part of those who enter the technical schools are comparatively young students with often only a scanty equipment of fundamental knowledge. They enter on a technical course of training with a view to utilising that training afterwards as a means of livelihood. Very few of them mean to be machinists, moulders, engineers, carpenters, or mechanics of any kind. Many of them aspire to positions of responsibility and trust in manufacturing establishments, and by coming to the technical schools instead of serving an apprenticeship in the works they virtually pronounce it their opinion that, all things considered, this is the better and surer course to take.

If this is a fair statement of the case—and I think it will be generally accepted as such—we should expect to find the technical schools planning their work and adjusting their equipment to meet the requirements of such a class of students as has been sketched. Educational institutions are moulded not by trustees or founders in most cases, but by students. If, then, we enter upon any discussion of the methods and appliances of the school shops, it is clear that we must consider them from this point of view—not as training schools for mechanics, but as having in view the development of men more particularly fitted to deal with wholes rather than with their parts. The question is, then, Are the methods and appliances of the school shop adequate to the task of producing men capable of taking important positions without considerable supplementary experience in the works? First of all we must inquire, What are the qualities which such a position demands in him who holds it?

To begin, he must have a certain just and well-earned independence—or, better, freedom—of thought and judgment. In the second place, he must be far-sighted, able to see over the heads of his men, planning far in advance such changes as will be necessary to meet the demands of the times, always watching tendencies and not the mere order of events. He need not be an especially skilful mechanic himself, but if he can add this to the foregoing qualities it will certainly increase his efficiency. Finally, he must command the respect and regard of those under him, and have the power to make them enter into his ideas and work out his plans. Such, broadly speaking, are the qualities which must characterise a man who holds any responsible position in a manufacturing establishment. Now let us analyse these requirements, see how they may be attained, and judge, as well as we can, whether the technical school shops are likely to furnish the requisite conditions.

Independence of thought and judgment usually comes from two things—experience and much thinking. Neither one alone can bring it about. The same is true, only perhaps in a higher degree, of far-sightedness. The other essential qualities mentioned are, I think it will be conceded, largely matters of temperament and disposition.

How much, now, can the technical school do toward equipping a man with such qualities? Can it, in the first place, give experience? If so, to what extent? This question has been discussed over and over again. The very best engineers in America have devoted special sessions of their meetings to it, but I cannot find that it has been seriously maintained that the amount of work done by a student in the shops of a technical school can be taken as so much practical experience. The time is too short, the view too limited, and, moreover, there is lacking in most cases the reality of actual shop-work. The most serious obstacle, indeed, to the successful employment of the school shop as a means of actual practical experience is found not in the shop itself, though it has its limitations here, but in the student and in the atmosphere of student life. We may talk, if we please, about the earnestness of students, and may fancy, if we see fit, that we find more of this desirable element in the technical school than in the college, but as a matter of fact every year sees less and less difference between the institutions in this respect. In both of them conditions have changed considerably within the last ten years. The life of the student is more complex now than it formerly was, and the element of *study* is only one among a number, all of which demand some attention. As a whole the change has probably been a beneficial one, but we certainly have been obliged to forfeit something. Then, again, the very largely increased number of students, which is such a perplexing element in the educational problem to-day, has tended, as it must necessarily do, to make classes more unwieldy and work of all kinds more mechanical. Nor can it be truly said that the laboratory and laboratory instruction have escaped this. Every one who is connected with such instruction knows that most students regard the work simply as a set of things to be done, and in the doing of which they must attain a certain degree of accuracy. The question that the teacher hears most of in the laboratory, and that depresses him most, is, "Will this do?" or, "Is this good enough?" The mischief is often done, moreover, before the man gets to the college or the technical school. Their influence and traditions reach far back to the boy in the grammar school, and in most cases when he comes to college or to his special school, whatever it be, he is entirely *au fait*, and settles into the harness immediately with a pretty good understanding of what will be required of him, and how he can meet requirements most easily.

To some extent, then, we must take this matter into consideration. A young man working at his bench in the machine-shop of a school is a *student*, and lives the life and thinks the thoughts of a student. Put the same man at work where he can barely earn a living, and where a mistake means so much spoiled material and wasted time, and may cause him to be put back, and he is obliged to labour in a very different way. It is one thing to stand over a steam-engine, take a few cards, adjust a valve, set an eccentric, or scrape a bearing in the engine-room of the technical school, and quite another thing to stand over a fast engine driving machinery which *must not* stop and which has obligingly taken the opportunity to develop a hot crank-pin or a broken piston-ring. The mere agony of soul of such an hour calls out a man's resources as never before.

It is hardly possible to emphasise this point too strongly. The difference is not so much in the things done as in the attitude and standpoint of the man himself. If we undertake to criticise the equipment of the school shop and the plan of work therein carried out as if the fault were to be found there, we shall find our task a very difficult one. The tools and machines are in most cases excellent. If any criticism at all were to be made perhaps the most just one would be that the machines and tools are a little too good. It certainly is a matter of experience that the best kind of apparatus for a beginner to work with is such as makes success depend, in the main, upon his own judgment and skill in handling it. The best training in measurement is afforded by comparatively rough instruments, stress being laid mainly on the point that with instruments of a certain degree of correctness we can reach a result of a certain order of accuracy. By studying carefully the conditions we can perhaps improve our first results a little; but ultimately we reach a well-defined limit which can be passed only by using better instruments. If this step be taken, and the possibilities and limitations of the problem be studied anew in the light of the increased field of errors introduced by changing to more delicate instruments, we can attain to a result which will be of a higher order of accuracy than the first one. I believe this principle could be applied with great advantage in some lines, at least, of shop-work. I have many times noticed in graduates of technical schools a tendency to use instruments in an unintelligent way. For instance, I have seen indicator-cards figured to $\frac{1}{1000}$ of a horse-power when the reducing gear was very loose on centres, and the cylinder had not been measured. I have seen measurements made with a wooden ruler graduated to $\frac{1}{8}$th of an inch recorded to hundredths of an inch. I have seen the weight of cast-iron pieces calculated to the thousandth part of a pound with no real knowledge of conditions which would warrant such exactness of statement. Such performances are not by any means uncommon. One of the rarest sights to be seen in any kind of laboratory, mechanical or otherwise, is a student whose work is *consistent* throughout, and who has the judgment to carry his measurements to a point indicated not by the limit of the graduation on the scale, but by his own clear perception of the conditions, requirements, and possibilities of the case.

I believe that a student will make better progress in this direction with rather rough instruments, but much can be done toward cultivating the corresponding habit of mind, no matter what kind of instruments are employed. So also with machine work. It is not so important that a young man come from his shop training able to make a good fit as it is that he be able to rightly estimate the real accuracy of his work. Let him be taught that he is not to ask his instructor whether the work is "close enough." He is to know for himself just how close it is, and just how well it meets the requirements of the case.

Students differ very widely in this respect. Some need only a hint, and never lose sight of the idea, which fits perfectly into their natural ways of doing things. Others learn only in a sort of automatic way, and never work with any freedom. It is vain to expect anything different. The engineering sense is, to a great extent, born in a man. If it is there, it will permeate any kind of a course of training whether taken at the apprentice's bench or in the shop of the technical school. If it is not there, no amount of training can *create* it. Some men who have had all the advantages of both school and shop experience seem never able to grasp firmly fundamental principles. One designs his first machine without any due appreciation of the fact that strength is good only when it is in the right place—when it is actually opposed as a resistance to deflecting or distorting forces. Another, carried away by his interest in designing a certain piece, or carrying out a certain idea, emasculates his work by too much detail and wastes time and material on something which, when completed, is only a blunder. Or there is a failure, through short-sightedness, to provide for all the requirements. I recently saw a newly-designed tram locomotive in which the generally desirable quality of rigidity had been

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carried so far that the machine refused to go round a curve. Such mistakes as these do not always come from a lack of what I have called the engineering sense. Quite frequently they simply indicate the lack of a kind of experience which is only obtained by close and living contact with actual conditions as they are found in practice.

It is clear now, I think, that most of the qualities necessary to a man who is to take a responsible part in mechanical matters are such as belong to a somewhat mature mind. In most cases time and experience only will bring such maturity, but certain it is that the school, and particularly the school shop, can bear a very important part, not only by supplying elementary knowledge, but by inducing in the student habits of mind which will follow him into active life. This, it seems to me, is the natural function of the technical school. While a man remains a student he thinks and works as a student. He is impressed mainly with the multitude of facts surrounding him. He deals largely with books and thinks in book form. He has little experience to go on, and so lives largely in the experience of others. All this is well if only his eye penetrates behind the practice and grasps the principle. Sometimes this is the case, but not generally. Whatever else may be said of the atmosphere of the modern technical school, it is not a reflective one.

Just here the influence of the teacher cannot be too strongly emphasised. If he is himself a practical man in the true sense, possessed of a clear head and of creative energy, one who has been accustomed to deal with facts at first hand, he can, if he has the spirit of a true teacher, impart to his students something of his own mental stamp, so that they too will think for themselves, and all their work will show the freshness of *real* originality. It has always seemed to me, moreover, that the students might profitably be thrown on their own resources more than is generally the case. Of course, the chief obstacle to doing this lies in the effort to get a class over a certain amount—generally a considerable amount—of ground in a given time. It is just this effort that should be especially deplored as fatal to the attempt to turn out clear and independent thinkers. It is neither in amount of work done nor in multitude or completeness of appliances, but in the moulding and enlarging influence of an inspiring teacher that the chief possibility of the technical school is to be found.

To sum up: the technical school furnishes, in its machine-shop, a laboratory, not an apprenticeship. Its constituents are students and its atmosphere that of a school. The instruction offered is, so far as courses and appliances are concerned, about as "practical" as it can be, and it should be of great value as a preparation for all grades of mechanical and technical work; but in precisely those points which are most indispensable to the training of a thorough mechanic, or, indeed, to any person who is to take a responsible position in mechanical matters, it is deficient. From this statement of the case we should be led to expect what experience confirms, namely, that in a considerable majority of cases the technical school graduate needs a supplementary apprenticeship before he is fit to take the position of foreman or superintendent. There are exceptions, of course. I have myself known one or two such cases.

Finally, anyone looking over the problem of technical training, and inquiring how its work must be planned so as to do for a young man the most possible in a given time, can see many things that would be desirable if practicable. For instance, it would be desirable if students could come with more of a good foundation of general education under them. We in the colleges echo the wish, but it sometimes seems as if every tendency were in the opposite direction. It would be a great step in advance if men would come to the higher schools mature enough to know what they can do and what they want to do. Then if instructors could only tell certain students that they have no business in a technical school and never will have—not roughly, but kindly—and give them some advice as to what they had better do; if, in short, there could be more *selection*, and the numbers to be handled reduced somewhat—everything could be done better. As things are now constituted and now tending, it does not seem as if much could be done in any of the above directions. How much difference it would make in the situation if the technical schools really tried to be *selective* is a question. The experiment is certainly impracticable under existing conditions, but one can hardly help wishing it could be tried. One thing is certain: minds cannot be trained by machinery, and in general, as our educational institutions become more crowded, instruction will certainly become and is now becoming more and more machine-like. If the time ever comes when the colleges and technical schools are less crowded, and when more men stop with an ordinarily good high-school education—a state of things which would have its advantages—there is no doubt but more will be accomplished in the line of making thinkers in both technical school and college. Either this must be the case, or evolution must work some change in the coming student, by virtue of which he will be led to reflect and think under conditions not favourable to the student of to-day.

GAS *V.* ELECTRICITY.*

After the very able exposition of "Gas *v.* Electricity" by the President of the Gas Institute (Mr. Denny Lane) this year at Belfast, I fear there is little ground for me to touch on the subject. I should like to reiterate, however, in as clear a manner as possible, the relationship in the cost of the rival lights to the consumer, *i.e.*, light for light. This has hitherto been stated more or less clearly, and sometimes with a certain vagueness on account of the technicality of the subject. Perhaps the following table will emphasise the information in as lucid a manner as it can be stated:—

Comparative Cost of Gas and Electric Light.†

Electric lighting at 6d. per Board of Trade unit.		Gas (16-candle) at 2s. per 1,000 cubic feet.				
		Ordinary open flames given by burners.		Standard Argand burner.	Regenerative lamp.	Incandescent gas light.
		As commonly used.	Adapted to pressure of gas and light required.			
Number of units said to be equivalent to 1,000 cubic feet of 16-candle gas.	Cost.	Candle-power per cubic foot of gas consumed.				
		1½ to 2	2½	3⅛	10	20
Allowed by Board of Trade } 10	5/-	3/10	2/4	2/0	-/8	-/4
Practical men estimate..... } 12½	6/3					
One-sided advocates say ... } 6	3/-					

It is thus that electricians compute (the 3s. 10d. against the 3s.) the cost of their light being "cheaper than gas." Their assumption of 6 units instead of 10 units, allowed by the Board of Trade as being equal to 1,000 cubic feet of gas, is a wilful playing with "standards of light." It is, however, done with the greatest *sang froid*. Were the gas industry to be as guilty of misrepresentation it could with all reason adduce the latest development in economical lighting by gas, viz., the incandescent light, which reduces the cost to one-sixth of our standard, or one-fifteenth of the cost of electric light. The fair way to put it, however, is: Gas standard, 2s.; electric light standard, 5s.—*i.e.*, electric light two and a-half times the cost of gas, light for light.

There are about 600 towns which may be expected to use the electric light, if it were a success commercially; but only 5 per cent. of these as yet have each a comparatively small installation. The average proportion of light in such towns is 2 per cent. electric light, and 98 per cent. gas light. Taking the proportion of electric lighting for the whole country, we find it would be 1 per cent., against 99 per cent. of gas light in use. This year 18 towns have applied to the Board of Trade for powers, against 24 the year before—out of the 300 to 400 which "intended" to apply. As the number of towns experimenting with the new light is in a decreasing ratio, this shows that it has reached its level, and that it now appears in its proper guise in the estimation of those who may adopt it, if not in that of the electrician and capitalist.

I would commend those towns about to adopt an electric light installation to note what was published a few weeks ago from the home of electric lighting—America—where it has got such a foothold; gas being three to four times the price paid in this country. It is said that "33 out of 56 electric lighting companies doing business in Massachusetts did not pay any dividend last year, while the average dividend paid for the year by the whole 56 companies (as many as are working in this country) was only 0·0235 per cent."

In these few sentences I have endeavoured to place before you the status of the gas industry in regard to its manufacturing and distributing plant, as well as to our rival in the field—electricity. The adoption of prepayment meters meets the case of a greater competitor—oil—for domestic lighting. It also would soon fail, so far as economy goes, were gas consumers alive to the fact that they could light their houses, even with ordinary open-flame burners, at least 30 per cent. cheaper than they do at present, by simply using burners properly adapted to their requirements. It is well

* Abstract of the Presidential Address by Mr. D. Terrace, read before the North of England Association of Gas Managers.

† [This table, which is anything but lucid as it stands, appears to be based on the cost of 3,333 candle-hours. It is referred to in our Notes.—Ed. *E.*]

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known that gas of (say) double the quality we supply is often deteriorated to less than half its value by consuming it under high pressure and in small burners; whereas both it and poorer quality gas can be readily made to give greatly increased lighting power, according to the means taken to secure this.

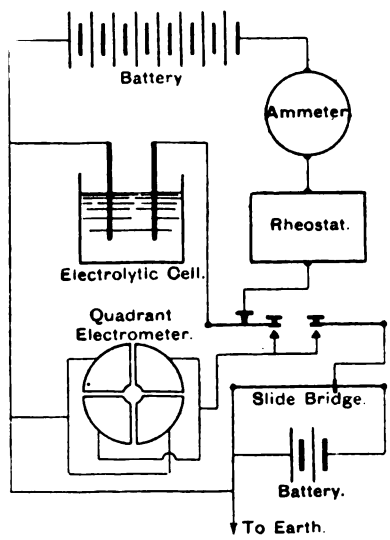
The future of electric lighting may be briefly summed up in the words of that great scientist, the late Sir C. W. Siemens, who said, when he was President of the British Association, in 1882-83: "Improved gas lighting may continue its rivalry with electric lighting, both as regards economy and brilliancy, and such rivalry must result in great public advantage."

POLARISATION OF PLATINUM ELECTRODES IN SULPHURIC ACID.*

BY JAMES B. HENDERSON, B.SC.

This investigation was begun about the beginning of February, 1893, at the instigation of Lord Kelvin, and was conducted in the Physical Laboratory of Glasgow University. The object of the investigation was to obtain the difference of potential between two platinum electrodes immersed in a solution of sulphuric acid immediately after the stoppage of a current which had been electrolysing the solution, and to find how this difference varied with a variation in the intensity of the current or in the strength of the solution.

Former experiments by Buff † and Fromme ‡ have given for the maximum polarisation with platinum wires of very small service in the electrolysis of dilute sulphuric acid 3·5 and 4·6 volts.



The cell used in the present investigation was a cylindrical glass vessel 10cm. in diameter and 12cm. deep. The electrodes were rectangular plates of platinum foil 7cm. long by 5·5cm. broad, and were stiffened by being mounted on rectangular frames made by bending glass tubing. The plates were immersed in the solution to a depth of 5cm., having their planes parallel and about 1cm. apart. There were thus 55 sq. cm. of surface of each plate wetted. To find the polarisation one of Lord Kelvin's quadrant electrometers was used, and by an arrangement described later, the breaking of the electrolysing current circuit and the switching of the electrodes on to the terminals of the electrometer were done simultaneously. Before switching as above, however, the needle of the electrometer was deflected by making a difference of potential between the pairs of quadrants, and this deflection was so adjusted by trial and error that, when the electrodes were switched on the needle was no farther deflected. For deflecting the needle of the electrometer a high resistance slide bridge was used. A difference of potential was maintained between its two ends, and the difference of potential between one end and the slider was used to deflect the needle, so that by moving the slider one way or the other the deflection could be increased or diminished at will. The electrolysing current was kept constant throughout each experiment, being measured by one of Lord Kelvin's electric balances, and adjusted by a rheostat. One terminal of the electrometer, one electrode, and one end of the slide bridge were connected together and then put to earth. The current for the electrolysis was got from eight large secondary cells, and the difference of potential between the ends of the slide bridge was maintained by two small secondary cells. The arrangement of keys can be understood from the diagram. By pressing the key k', connection was made between the slider and the unearthed quadrants, and when the key k was free the circuit was complete for the electrolysing current, but when k was pressed down the circuit was broken, and the unearthed electrode was connected to the unearthed quadrants.

The order of an experiment was the following:—

After standardising the electrometer by means of a Clark cell the electrolysis was started, and the unearthed electrode connected by a wire (not shown in the diagram) to the unearthed quadrants. The deflection of the needle thus produced, which showed the difference of potential between the electrodes, continued to increase steadily until, after the lapse of an interval of time depending on the strength of the current, it became constant. When this stage was reached the wire mentioned above was removed and the key k' pressed and kept down, thus making connection between the slider and the quadrants. The slider was then moved along until the deflection was nearly equal to that which would be given by the polarisation, and the key k momentarily pressed, thereby breaking the current circuit and connecting the electrode to the quadrants. An impulsive deflection immediately followed, unless the potential of the quadrants was equal to that of polarisation. If this deflection was negative (which indicated that the potential of polarisation was less than that of the quadrants) the slider was moved so as to reduce the potential of the quadrants below that of polarisation, thereby making the impulsive deflection positive, and then the experiment was continued as below. When the positive deflection was obtained its amount was noted, and the slider was moved so as to increase the steady deflection nearly up to the point on the scale reached by the impulsive one, and another trial then made. In this way, by watching the point reached by each impulsive deflection, and then increasing the steady one almost up to that point, the latter was increased until the former vanished—that is, until the potential of the quadrants was that of polarisation. The magnitude of this deflection was then noted, and the polarisation calculated from it. In these trials the key k was kept down only for about two seconds, just sufficient time to allow the extent of the deflection to be seen, and at least two minutes were allowed to elapse between one trial and the next.

After the maximum deflection had been reached a considerable interval of time was allowed to elapse, and then the key k' raised and k simultaneously lowered and kept down, and the rate of fall of the deflection noted. The above motion of the keys threw the slider off and put the electrode on to the quadrants, at the same time stopping the current. The deflection was therefore due to polarisation alone, and its rate of fall was therefore the rate of fall of the polarisation.

The results of one series of experiments are given in the accompanying table.

All the results point to the polarisation being constant with large electrodes, being independent of the strength of the solution and the intensity of the current. The variations in the figures do not occur in any order, and are all such as might be expected in experimental results of this nature. Some of the greatest variations were obtained in exactly similar experiments performed at different times.

The mean of all the values of the polarisation in this table is 2·09 volts.

The rate of fall of the polarisation depends on the time the current has been electrolysing the solution, and also on its intensity; but in every case the fall is very rapid at first, being in some cases as much in the first minute as it is in the next five minutes; and the fall in the first minute is never less than one-fourth of the polarisation.

Percentage strength of solution.	Strength of current in amps.	Deflection for Clark cell.	Deflection for polarisation.	Time the current had been passing. H.	Time the current had been passing. M.	Polarisation in volts.
30	0·2	111	160	3	25	2·066
,,	0·5	110	158	0	45	2·060
,,	1·0	110	158	0	35	2·060
,,	1·0	108	160	0	45	2·124
20	0·1	120	178	3	22	2·126
,,	0·5	120	179	1	25	2·139
,,	1·0	107	156	0	25	2·090
,,	1·0	108	160	0	35	2·124
10	0·1	120	179	17	40	2·139
,,	0·5	120	173	1	19	2·066
,,	1·0	120	173	0	44	2·066
5	0·1	124	183	18	30	2·116
,,	0·5	118	171	1	36	2·078
,,	1·0	117	170	1	0	2·083
,,	1·0	120	172	3	15	2·054

Mean polarisation = 2·09 volts.

* Abstract of Papers communicated to the Royal Society.

† *Poggendorf*, Vol. CXXX., p. 341, 1867.

‡ *Wiedemann*, Vol. XXXIII, p. 80, 1888.

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ALTERNATE-CURRENT WIRING.*

BY W. D. WEAVER.

The following tables, calculated from Kennelly's formula,† give the increase of drop due to impedance in circuits carrying alternating currents. Each table is for a different frequency, as given: the first two vertical columns of a table give the gauge of wire, the horizontal column at the top the distance apart of the two wires of a circuit, and the other columns the coefficients by which the drop due to a continuous current should be multiplied to find the true drop if an alternating current is used. To lower the drop due to impedance it will be seen that large wires should be avoided. In inside work particularly a considerable saving of copper may often be made by dividing the feeders of mains into several circuits. The following method will enable the tables to be applied with an approximation sufficiently close for practical purposes:—

(1) By means of one of the usual formulæ, calculate, for the given lamps, amperes, or horse-power, the size of the wire (in circular mils) as if a continuous current were to be used, and from a table giving the gauge equivalent find the nearest corresponding gauge number.

(2) Enter with the gauge thus found that one of the following tables which corresponds with the periodicity used and take out the corresponding coefficient.

(3) Multiply the original circular mils by this coefficient and find the corresponding gauge again as above.

(4) Repeat the operation of (2).

(5) Multiply the original circular mils by this second coefficient and proceed otherwise, as in (3).

Forty Periods per Second.

Nearest S.W.G.	Gauge B. and S.	Distance between wires.			
		3in.	12in.	100ft.	1,000ft.
000000	0000	1·38	1·73	3·13	3·87
0000	000	1·27	1·53	2·59	3·10
000	00	1·17	1·34	2·13	2·50
0	0	1·12	1·25	1·83	2·17
1	1	1·09	1·18	1·58	1·83
3	2	...	1·12	1·41	1·59
4	3	...	...	1·28	1·41
6	4	...	...	1·19	1·26
7	5	...	...	1·12	1·19
8	6	...	...	...	1·12
10	8	...	...	...	...

Eighty Periods per Second.

Nearest S.W.G.	Gauge B. and S.	Distance between wires.			
		3in.	12in.	100ft.	1,000ft.
000000	0000	2·10	3·00	6·01	7·54
0000	000	1·86	2·51	4·87	6·04
000	00	1·61	2·05	3·91	4·69
0	0	1·46	1·83	3·31	4·46
1	1	1·32	1·59	2·66	3·23
3	2	1·23	1·42	2·22	2·66
4	3	1·16	1·29	1·88	2·43
6	4	1·11	1·20	1·62	1·84
7	5	...	1·14	1·43	1·62
8	6	...	1·09	1·30	1·42
10	8	...	...	1·13	1·19

One Hundred Periods per Second.

Nearest S.W.G.	Gauge B. and S.	Distance between wires.			
		3in.	12in.	100ft.	1,000ft.
000000	0000	2·58	3·67	7·48	9·40
0000	000	2·20	3·05	6·04	7·51
00	00	1·84	2·45	4·88	5·81
0	0	1·66	2·16	3·98	4·91
1	1	1·48	1·84	3·23	3·98
3	2	1·34	1·61	2·67	3·24
4	3	1·24	1·43	2·23	2·67
6	4	1·17	1·30	1·88	2·17
7	5	1·11	1·21	1·62	1·87
8	6	1·09	1·14	1·43	1·62
10	8	...	...	1·20	1·29

* From the *Electrical World.*

† $f = \sqrt{1 + \frac{p^3 \pi^2 r^4 (0{\cdot}5 + 2\log_e \frac{D}{r})}{\rho^2}}$ (Kennelly on "Impedance," *Transactions* of the American Institute of Electrical Engineers, April, 1893).

If thought necessary, a third or fourth approximation may be made by repeating the operations indicated in (4) and (5). The above rules and tables apply to alternating currents that can be represented by simple sine waves. If the current waves are of more complex type, the drop due to impedance will be increased. The above values are therefore minimum values. The tables are based on the assumption that the current density in the conductor remains uniform. With the frequencies used the error introduced by this assumption is negligible as relates to the calculation of impedances as well as to the increase of drop due to the unequal distribution of current in the conductor.

THE MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.*

The seventy-ninth meeting of the American Institute of Electrical Engineers was held at its headquarters in New York, on September 20, 1893, with President E. J. Houston in the chair. Some discussion was caused by the action of the Council in ordering to be printed, without reading, a Paper of a non-member of the Institute which had been read before another society. The Paper referred to was one by Dr. W. J. Morton on "A Brief Glance at Electricity in Medicine," which was read before the New York Electrical Society on May 17th. Mr. T. D. Lockwood protested, in vigorous terms, against permitting a Paper read before another society to be thus published at the expense of the Institute, and asked if the Editing Committee had consented to the publication of the Paper. While acknowledging the high scientific acquirements of Dr. Morton and the great value of the Paper itself, Mr. Lockwood challenged the right of the Council to thus establish a precedent for printing Papers of another society, or of non-members, in the *Transactions*, and at the expense of the Institute. The Chairman explained that Mr. T. C. Martin had asked Dr. Morton to prepare a Paper for the Institute, and that the authoritative character of the Paper in question was thought by the Council so great as to warrant its being printed in the *Transactions*. Mr. G. M. Phelps asked that the discussion be ruled out of order, and a motion was finally adopted to proceed to the reading of the Paper on the programme. Mr. D. McFarlan Moore read his Paper on "A New Method for the Control of Electric Energy," in which a vibrating device was described for regulating voltage. The apparatus consists of a vibrating armature, whose rate of vibration is controlled by approaching or receding the core of a magnet; at each vibration a circuit is made and broken, or the contact pressure is varied, although the author did not conclusively show that this latter principle entered. Aside from the author's explanation, it would seem that the reduction in voltage is caused partly by the magnet windings acting as a choking coil, and partly because the effective E.M.F. is reduced to the square root of the sum of the squares of its value at different times, these values varying from a maximum to zero. President Edwin J. Houston then delivered his Inaugural Address, the subject being "The Chicago International Congress," which dealt in a masterly manner with the work of the Congress, pointing out in what respects it succeeded and where it failed, and referred in glowing terms to the great accomplishments and magnificent possibilities of electricity. The address was received with great applause, and Mr. T. D. Lockwood, in his usually felicitous manner, moved a vote of thanks, which was seconded, and unanimously and cordially adopted. At the conclusion of his Address Prof. Houston called attention to the great desirability of standards of light and illumination, a matter upon which the Electrical Congress had arrived at no conclusion, and requested authority to appoint a committee composed of members having facilities for carrying on the necessary experiments, for the purpose of making a thorough and scientific investigation of the subject, in order that the institute may be able to submit a definite programme to electrical bodies throughout the world for discussion with a view to final adoption. He stated that Mr. Preece had consented on his part to co-operate in England with the Committee, and to undertake experiments with the same object in view. A motion granting the necessary permission to appoint and instruct a committee was later seconded and unanimously adopted. During the discussion on Mr. Moore's Paper the Chairman noticed Mr. Preece among the audience, and invited the distinguished honorary member of the Institute to a seat on the platform. Upon the conclusion of President Houston's remarks, Mr. Preece was asked to address the meeting, which he did in a graceful, pointed, and witty manner, which has established his reputation as one of the most effective and versatile speakers in the scientific circles of England. He referred to the great pleasure which he had derived from his latest visit to America, and also to the great professional benefit gained from it. He spoke of his proposition to co-operate with the Insti-

* From the *Electrical World.*

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tute in its endeavours to establish units of light and illumination, and alluded in particular to the great desirability of establishing a unit of illumination. The address of Mr. Preece was in an especially happy vein, and left the impression with some that it was perhaps well for "Our Chauncey" that circumstances prevented the distinguished Englishman from coming into direct rivalry with him. Mr. C. P. Steinmetz brought to the attention of the Institute the desire of some fifteen members of the Institute at Lynn (Mass.) to hold local meetings at that place.

THE NEW BRUSH 125-ARC LIGHT MACHINE.*

In general appearance this machine does not differ materially from the usual type of Brush arc machine, but on close examination it shows some departures from the method of construction heretofore adopted. The machine has four poles, and the armature is cross connected, so that only one set of brushes is used with the usual three rings, each ring having eight segments. The magnet cores are of soft steel. The armature has been subjected to a special study in this machine, owing to the high voltage employed, and for the particular purpose of reducing the sparking at the commutator. In the old type of machine, it will be remembered, the shape of the sheet-iron pieces which make up the core was such as to make up a uniform cylindrical surface, as shown in the engravings, Figs. 1 and 2, which illustrate, respectively, a side and an end view of a portion of the old-style armature. In order to make the line of commutation as sharp as possible, the armature core plates of the new machine have been tapered off on both sides between each pair of the coils, presenting the appearance shown at A in Fig. 3. With this

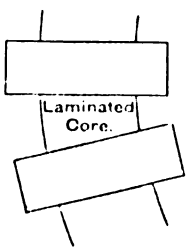

Fig. 1.

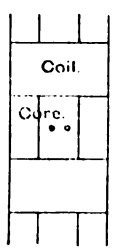

Fig. 2.

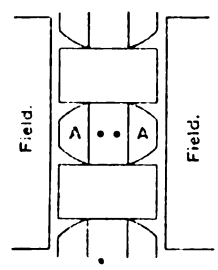

Fig. 3.

construction the result has shown that the sparking is greatly reduced. The armature is wound with 24 bobbins having 528 turns each, of No. 14 wire. Each of the field cores is wound with 1,560 turns of No. 8 wire. The whole machine weighs 9,000lb. has a 38in. by 44in. base, and is 4ft. high. These dimensions are smaller than those of the No. 8 Brush 65-lighter, which was 87½in. long. The total length of the new machine from pulley to commutator is 84in. The combination as it stands, engine and dynamo together, occupies a floor space 4ft. by 11ft. The machine is designed to give 6,250 volts at 525 revolutions, but the engine to which it is coupled, being designed for only 460 revolutions per minute, allows the dynamo to generate only 5,200 volts, equivalent to 100 lights. The external characteristic of this machine is highly remarkable, showing the perfection to which this type of apparatus has been brought. In a recent test made at the engine works of the Bullock Manufacturing Company, the output of the machine was varied between 4·29 and 12·1 amperes. The curve representing the amperes rises gradually up to a point represented by 9·4 amperes and then falls abruptly. The curve is almost an ideal one, and represents the great desideratum in an arc lighting machine, and one especially, in which the voltage is as high as it is in this case. The engine to which the dynamo is connected is of the well-known Willans type.

Gutta-percha.—A process has been invented by M. Rigole, of France, for extracting gutta-percha from the leaves and twigs of the *Isonandra dichopsis*. This process will, it is claimed, ensure an unlimited supply of gutta-percha in a few years' time, as it allows of the trees being utilised continuously during the whole period of their existence, instead of being cut down and destroyed for a single yield of gutta-percha, as is now done. An estate has been selected in the island of Pulo Obin, near Singapore, for the establishment of a plantation and factory. A process, having for its aim a similar prolongation of the tree-life, and invented by M. Sérullas, was described in *The Electrician*, Vol. XXIX., page 302.

* Abstract from the *Electrical Engineer* of New York.

OPENING OF THE DERBY ELECTRIC POWER STATION.

On Tuesday evening last, the 10th inst., the new electric power station at Derby was formally opened by the Mayor of that town. The site chosen for the generating station is close to the river, at the place where the Old Silk Mill formerly existed, and is well suited for coal and water supplies. When complete the station will be equipped with 13 engines, each driving a separate alternator, but at present only six of these have been fixed. The engines are of the vertical compound type, of from 50 to 100 H.P. They are supplied with steam at 130lb. pressure from Lancashire boilers fed with fuel by Vickers' mechanical stokers. The entire system of supply is by means of alternating currents, the very low frequency of 40 ∿ per second having been adopted throughout. The street lighting is by arc lamps, each of 2,000 c. p., arranged in series of 35 lamps. The public supply is on the high pressure sub-station system, provision having been made for ten transformer sub-stations. The feeders are at 2,000 volts, and the low pressure network is maintained at from 100 to 105 volts. The capacity of each sub-station is equal to 1,200 8 c.p. glow lamps. The station and distributing plant have been carried out to the designs, and under the superintendence of Messrs. Bramwell and Harris.

MUNICIPAL SUPPLY STATIONS, GAS ENGINES AND ACCUMULATORS.

The question of the connection of gas engines with electric supply is one which has often been discussed in these columns, but the following abstract from a Paper by a German author presents some figures which may be interesting for purposes of comparison:—

There can be little doubt that in many country towns the combination of gas with electric supply would increase the companies' revenues, and form the basis of a sounder business than the supply of gas for illuminating purposes is ever likely to prove under such circumstances. Information on this subject has been recently supplied by the Accumulatoren-Fabrik Hagen. The first point to note is the great increase in efficiency of gas engines of late years, in regard to which Herr von Oechelhäuser, a well-known authority on gas manufacture and use in Germany, in a Paper read recently, referred to the old, but now erroneous, rule that one cubic metre of gas per hour develops one horse-power; whereas at present quite small engines give one horse-power for 800 litres, and larger ones are guaranteed to evolve one horse-power per 650 litres. The improvement is enormous, and cannot fail to react on the use of the gas engine. And the second point of almost equal importance is the increase in the size of the engines, which renders a larger unit of supply possible than was formerly the case.

Take, as an illustration, the following case. In the town of Dessau is an installation, worked by Otto gas engines amounting to a total of about 180 H.P. In the year 1887 these engines used on an average 953 litres per horse-power-hour; in 1891 this had been reduced to 730, and in 1892 to 710 litres. As unit in this station is used a "Deutz" gas dynamo of 120 H.P., having a "Fritsche" disc-armature, which at 145 revolutions per minute uses a cubic metre of gas for 905 watt hours—that is, about 30 litres per 30-watt lamp-hour; and another German firm (Körting Brothers, Hanover) gives the same figure as the efficiency of its larger gas dynamos.

English practice differs so widely from German in the matter of electric supply that the cases taken as illustrations are often inapplicable in their present form; but they may be made, *mutatis mutandis*, to supply subjects for reflection to the British engineer. With this preface let us proceed to the pamphlet of the Accumulatoren-Fabrik Hagen.

In order to economise in copper as much as possible, says the *brochure*, it has been found necessary in large towns having distribution at 100 volts, either to make several complete stations independent of one another, or to make sub-stations with accumulators fed from the central station along special conductors, as in Düsseldorf and other towns lately described in *The Electrician*. The advantages possessed by the latter method are a saving in works costs, due to the smaller number of men employed and a saving in capital expense in boilers, &c., but these savings may be swallowed up in the cost of installing accumulators and charging mains, and in more or less heavy depreciation. The Accumulatoren-Fabrik therefore advocates the use of gas dynamos on the spot for the purpose of charging the cells placed at the sub-stations.

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For the sake of working out some sample figures, the authors have assumed a town in which electric lighting is the rule and not the exception, and have taken as the basis of their estimates of plant capacity a load-curve which is an average best-load day of the towns Dresden, Magdeburg, Bremen, Karlsruhe, and Hagen. It is obvious that the use of dynamos without accumulators would necessitate an expenditure in plant represented by the maximum load, and although this does not necessarily mean working the machines generally at light load, and therefore inefficiently, as the authors seem to suggest (for there is such a thing as parallel running in daily use) the capital expenditure is certainly increased. The authors suggest the obvious advantage of running the machines all day on the cells at an approximately constant load, charging them up during the hours of light load, and discharging during the time of maximum demand.

Now this arrangement means a uniform demand for gas, and ensures therefore that it is produced as cheaply as possible ; and in a great and increasing number of cases the gasworks are owned by the local authority, and therefore gas is cheap ; the authors have therefore taken 2s. 4d. per 1,000 cubic feet as an average price, to which we must add that in England the cost of gas to a local authority when made and used by itself would probably be much lower than this.

The authors proceed to sketch out a scheme for the lighting of a town of about 70,000 to 150,000 inhabitants. They suppose two stations, each containing three gas dynamos of 120 H.P. each, two supplying current to a simple three-wire system, and one as reserve. These machines would be capable of supplying about 30,000 8-c.p. lamps at once, or about 45,000 wired. The stations are supposed to be about three-quarters of a mile apart, the feeders have 10 volts drop at full load, and the lamp-pressure is 110 volts. The plant at each station would be three 120 H.P. gas engines (one in reserve), three shunt dynamos, 110 volts 700 amperes (one in reserve), one battery, capacity 4,600 ampere-hours, charging current 662, discharging 1,060 amperes.

Using the dynamos as motors, no separate machine is necessary for the purpose of starting the large gas engines. Each station feeds to three points in the network. As regards salaries, &c., the gas and electricity works offices are supposed to be in common, and the gas manager is also manager of the electricity works, at an increased salary of £75 per annum. The lamps are supposed to burn 750 hours per annum, a low value. The capital expenditure for these stations is figured out at about £75,000 ; while if 10d. per Board of Trade unit be charged the interest on capital, after paying all expenses, would be about 17 per cent. ; at 8·75d. it would be about 13 per cent., and at 6d. apparently about 4 per cent.

This result should be sufficiently encouraging to induce gas engineers to make serious efforts to displace the steam engine in this work ; for although the figures may be unconsciously biased, there can be little doubt that the question is no longer one of "the dim and distant future," but must soon enter the field of "practical politics." The advantages of the gas engine are obvious : there is no smoke trouble, and the simplicity and cleanliness would gladden the heart of many a station engineer. Dr. von Oechelhäuser, in the Paper before alluded to, sums up the advantages as follows :—The small space occupied, the small amount of water used, avoidance of haulage of coal, absence of smoke, no danger of explosion, small capital expenditure both on account of land, cables, and electric plant and buildings ; small amount of attendance required, and the certain and convenient control of the output at all hours, owing to the rapidity with which engines can be started. Very many of our local authorities are now in the throes of doubt as to what system of electric lighting to adopt, and it is very probable that some of them might do worse than combine their gas with their electric light supply ; at all events, the question is worthy of serious consideration, and that the system has a great future before it in this country will probably soon be evident to engineers.

PARLIAMENTARY INTELLIGENCE.

A report has been made by the Board of Trade of their proceedings under the Tramways Act, 1870, and the Gas and Water Works Facilities Act, 1870, during the Session of 1893. The number of applications to the Board of Trade for Provisional Orders under the Tramways Act, 1870, made in December, 1892, was seven, viz., Birmingham Central (cable), Blackpool Corporation, Great Yarmouth, Hull, Manchester Corporation, Plymouth Corporation, and South Staffordshire. All these applications proposed the construction of new tramways, being, in every case except Great Yarmouth, in extension of, or in substitution for, lines already in use. The Birmingham Central, Hull and South Staffordshire applications were ultimately dropped by the promoters.

Four Provisional Orders were granted by the Board of Trade, viz., Blackpool Corporation, Great Yarmouth, Manchester Corporation, and Plymouth Corporation. The Blackpool and Plymouth Orders empowered the Board of Trade to grant a licence enabling the local authorities to work the tramways on being satisfied that the lines could not be leased at an adequate rent. In the case of the Great Yarmouth Order, the deposit money not having been paid into Court, the Board of Trade were unable to submit the Order to Parliament for confirmation. A Bill to confirm the other three Provisional Orders was introduced in the House of Commons on May 5th. Petitions were presented against the Blackpool and Plymouth Orders, but were subsequently withdrawn, and the Bill passed through the first House unopposed. In the House of Lords petitions were again presented against the Blackpool Order by the promoters of the Blackpool, St. Anne's and Lytham Tramways Bill, and against the Plymouth Order by the National Telephone Company (Limited). New clauses and other amendments were agreed upon between the parties, and the Bill received the Royal Assent on August 24th.

During the Session a Joint Committee of both Houses was appointed to consider and report whether the granted statutory powers to use electricity ought to be qualified by any prohibition or restriction as to earth-return circuits, or by any provisions as to leakage, induction, or similar matters ; and, if so, to settle the necessary clauses. The Joint Committee recommended a form of protective clause, which, with slight modifications, was incorporated in the Blackpool and Plymouth Orders in lieu of clauses previously inserted.

The Tramway Orders Confirmation Bill (No. 2), suspended from last Session, was proceeded with under the resolutions adopted in the previous Parliament. The Somerton, &c., Order was again petitioned against in the House of Commons by Mr. J. H. Thring. The case was heard by a Select Committee, who reported in favour of the confirmation of the Order, subject to a provision which they inserted as to the width of the road on which the tramway is to be laid. The Bill received the Royal Assent on March 28, 1893.

CITY INTELLIGENCE.

The Commissioners of Sewers.

THE TELEPHONE TUBES AGAIN : A LIVELY DEBATE.

Mr. J. HARRIS inquired whether it was true that the Electric Lighting Company had been using the telephone tubes they had laid down in conjunction with the electric lighting tubes.

Mr. GORDON replied that he had heard it mooted that they were being used *sub rosa*.

Mr. WALLACE asked whether *sub rosa* was a new technical term for telephone tubes.

Mr. HARRIS then moved that the question should be referred to the Streets Committee for investigation.

Mr. WALLACE said surely the executive of the Commissioners would prevent such a thing being done, but he protested against a fishing inquiry being instituted by a committee without there being some decided information forthcoming. If the Commissioners was being played with, and the officers had neglected their duty——

The CHAIRMAN reminded Mr. Wallace that there was no charge against any officer whatever.

Mr. WALLACE (continuing) said he declined to accept loose statements upon the *ipse dixit* of any member.

Mr. Deputy SCOTT : May I ask what *ipse dixit* means? Will Mr. Wallace tell me if it is a new technical term ?

Mr. MORTON said that in the first instance the tubes for telephone purposes were put down in a surreptitious manner, and without the consent of the Commissioners. He had seen the plans.

Mr. Deputy SCOTT declared that the Company told the Commissioners the purpose for which the tubes which had been referred to would be used. It was said that the tubes were to be used for the purpose of managing their lighting, and that they were necessary. But whatever had been done had been for the benefit of the public, and if the Commissioners could get the use of the telephone at half the price it would have accomplished a good thing on behalf of the citizens. Besides, the Company had power to put in these tubes, and if it had not been done the whole of the streets would have been pulled up a second time. That being so, he desired to know whether on both sides the public convenience had not been considered. The tubes had been absolutely set out in the plans sent in to the Commissioners. They were displayed in the second set of plans.

Mr. BERRIDGE remarked that the tubes referred to were not laid for the National Telephone Company. The Company which was carrying out the lighting was in communication with a new company which, it was said, was going to give the public cheaper telephones ; but the Company had managed to square the new Company, and take over the tubes. There was not much chance, he thought, of the public getting any great reduction in the charge that the Telephone Company made upon them. He agreed with the member who declared that the tubes in question were not shown upon the first plan ; and why ? he asked, simply to give them the opportunity of creating a monopoly.

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Mr. SAYER pointed out that the Commissioners did not suppose that the Company was going to sell the tubes, which they had stated were to be used for the benefit of the lighting, but anything almost was better than having the streets pulled up again.

Mr. WALLACE moved that the question should be referred to the Engineers' Department for investigation.

The CHAIRMAN then put the amendment, which, on a show of hands, was lost. The matter was then referred to the Streets Committee.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 29, 1893.

Electric Railway Accidents.—The increasing number of accidents on electric street railway lines is causing attention to be strongly directed towards means for their prevention. While the newspaper press ascribes every accident to the "deadly trolly," as if the electric current were the cause, in all except very rare cases they result from the negligence or carelessness of people in crossing the track, or from collisions of the car, either through incompetence on the part of the motor-man or from derangement of the controller and brake. While the speed of electric cars is usually greater than that of horse cars, they are otherwise more difficult to avoid, the horses in the former instances answering somewhat as a guard. The Brooklyn city authorities are proposing that all cars shall be required to be furnished with a guard in front that will be almost in contact with the rails, and that the speed shall not greatly exceed that of horse cars. In view of a recent accident in Cincinatti where loss of control of a car on a steep grade resulted in the death of several people, the authorities propose that each car shall be required to be furnished with an air-brake.

The Underwriters' International Electric Association has issued some minor amendments to the rules adopted by it this spring, and adopted definitions for the word "approved" where used in the rules, which is recognised as a commendable departure. The rules of this Association have already been adopted generally by the fire insurance companies, and it is expected that in a short time no others will be in use in the United States.

The American Institute of Electrical Engineers at its recent meeting listened to a Paper entitled "A New Method for the Control of Electric Energy." It described a device for the regulation of voltage which is merely a vibratory bell mechanism in a vacuum.

The World's Fair authorities have just made public their awards, and from the meagre account at hand at the moment it appears that they include almost every exhibitor, but that special awards, not yet announced, will be made for special merit.

Electro-Synthesis.—Mr. S. B. Mulligan who has recently applied electrolysis to the synthesis of organic compounds on the lines already worked by Prof. Crum Brown and Dr. Walker in Edinburgh, has, says *Industries and Iron*, extended the organic compounds capable of electrolysis to other bodies than organic acids. Amongst these new bodies which are capable of electrolysis are ketones, sodium salts like that of malonic ether amides and nitro-paraffin derivatives. All these compounds are exceedingly weak acids, and their salts are very unstable. It is therefore interesting to know that they are capable of yielding synthetic compounds by electrolysis. The products obtained are the same as one would expect to be formed by the action of iodine on the sodium or silver compounds of the substances electrolysed. The yields from the iodine reaction are, however, generally better than those given by the electrical method, but in some cases the latter method has given rise to the synthesis of compounds when the iodine reaction has signally failed. The author is therefore, full of hope that a careful study of the conditions favourable to electro-syntheses of this kind will result in the new method forming a valuable adjunct to those already in the hands of organic chemists.

CORRESPONDENCE.

"NEW LAMPS FOR OLD"; AND THE CHICAGO LAMP TESTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Brooking's letter in your issue of October 6th shows that he has quite missed the point of my article which appeared in your issue for September 29th. Whether contractors should, or should not, have fitted up houses with more lamps, whether rooms which have been already wired and supplied with current are, or are not, sufficiently lighted are considerations wholly beside the points considered in the article in question. It was not better lighting that I advocated, but the production of the *same amount* of light for a less total yearly cost. And this I explained, for the reasons given, could be effected by the householder buying lamps marked for a lower pressure and lower candle-power than before, when he required to purchase new lamps. For example, if his house be supplied with 100 volts nominally, or practically with 101 volts, then he should in the future purchase not 100 volt 16-c.p. or 100 volt 8-c.p. lamps, as the case might be, but 97 volt 13-c.p. or 97 volt 6½-c.p. lamps.

Mr. Brooking says I advocated "over-running" glow lamps, but, as a matter of fact, I avoided the use of this word in the article because over running suggests "over walking" "over age," &c., and implies that the laws of nature, or an Act of Parliament, have decreed the particular pressure that must not be exceeded for each particular glow lamp. Whereas what particular glow lamp should be used to produce a given amount of light at a particular pressure is simply a matter of economy. The cost of the labour in exchanging lamps must, of course, be added to the price of the lamps themselves, and in the case of public halls where the lamps are supported at the end of long electroliers, the cost of this labour may be an important item, and will lead to the economical life of lamps being longer than in places where the lamps are easily accessible. But unless the lamps have been fixed in positions nearly wholly inaccessible, in which case the electrical adviser, instead of the lamps, must be changed to obtain economy, the economical life of lamps at the price now quoted (1s. 6d. a piece), will be far less than their actual life, with energy even as low as 4d. per Board of Trade unit.

As the only English member of Group IV. of the Chicago Electrical Jury, I feel bound, in justice to my colleagues in America, to give my reasons for thinking you mistaken in your editorial comments on the lamp tests which were started at the Exhibition at the beginning of September. You say, "Life tests of this sort, and with the arrangements for maintaining a perfectly steady pressure which have been adopted, can have nothing but a fanciful and fictitious significance, and will be no guide to either the engineer or the consumer, &c." Your objection to the pressure being maintained perfectly steady at each of the values specified by the makers of the lamps I do not follow, since perfect steadiness of pressure for many weeks appears to me to be one of the most important conditions to secure in lamp testing. Perhaps your objection is not to the pressure being maintained steady when the current is flowing, but to the lamps not being, as you complain in the earlier part of your criticisms, turned off occasionally, as in practice. But if that be your objection, is it not more imaginary than real, seeing that the programme of the tests states "at intervals (as small as convenient in the earlier days of the life test) each lamp will be removed from the test rack, placed on the photometer bench, &c.;" that is to say, the dynamo current flowing through each lamp will be interrupted at intervals to place the lamp on the accumulator circuit, or, in other words, each lamp will be periodically cooled as in practice.

"The maximum life under which a lamp can be tested will be about 1,130 hours," and that you criticise as too short. But at any of the present prices for electric energy the economic life of a lamp, even if it still cost 4s., would be

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much under 1,000 hours, and at the price now quoted (1s. 6d. per lamp) the economic life is almost certainly under 500 hours. Why, then, is 1,130 hours too short a time to employ in the tests?

If the tests on the 360 lamps selected from the nine most important American types be carried out as the programme directs, then so far from the results being "no guide to the relative merits of the lamps when at work on ordinary lighting mains," they will furnish much information which not only American, but also English, electric-light engineers are most anxious to gain. For the time has come when England can no longer afford to disregard the behaviour of cheap foreign glow lamps. Is, for example, the 8d. Westinghouse stopper lamp, of which so many thousands are being used in lighting the Chicago Exhibition, as efficient as a lamp made of glass hermetically sealed? Which of the two very different makes of glow lamp supplied by the General Electric Company of America is the better? How much truth is there in the printed statement issued by the makers of the Novak lamp: "It absolutely maintains its *initial candle-power* at its initial efficiency throughout its entire life?"

All these and, I hope, other questions, such as Do lamps run on alternate-current circuits last as long as on direct-current circuits? will be answered by these tests if they be carried on in the way they have been commenced. Tables, it has been decided, will be drawn up by the jury showing the price of a candle hour for many periods of the life of each kind of lamp, using a number of different prices for a kilowatt hour and a number of different prices for each type of lamp. The preparation, under many difficulties, of all the arrangements to enable the programme to be carried out occupied Prof. Thomas and his little band of fellow-workers many weeks, while the supervision of the tests will entail long journeys to Chicago by Americans engaged elsewhere. I feel sure, Sir, that *The Electrician* is too generous not to withdraw its condemnation of labours undertaken by men fully as enthusiastic and untiring as the workers of Great Britain, and whose love of the old country makes them keenly sensitive to undeserved harsh criticism of its Press.—Yours, &c., W. E. Ayrton.

October 7, 1893.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

"Drum Armatures and Commutators."—This book, which is written by Mr. F. Marten Weymouth, and is the latest addition to *The Electrician* Series, is now ready, and will be sent direct by the publisher on receipt of the published price, 7s. 6d., or it may be obtained from any bookseller. A prospectus will be forwarded on application.

Tenders Invited.—It will be seen by our advertisement columns that the Postmaster-General desires tenders (A) for the supply of red fir telegraph poles, to be delivered in London, King's Lynn, or Sutton Bridge, and at Northumberland Dock (River Tyne), West Hartlepool, Hull, or Grimsby; and (B) for creosoting the poles. Forms of tender, containing all particulars, to be obtained on application to Mr. Chas. E. Stuart, Controller of Stores, Telegraph-street, London, E.C., and tenders must be in by noon on the 30th inst.

——— The Rivers Committee of the Manchester Corporation are prepared to receive tenders for supplying and fixing electrical plant, vertical engine dynamos, accumulators, and all necessary connections and appliances required to light the sewage works at Davyhulme. Copy of specification, and all particulars, may be obtained from Mr. John Allison, city surveyor, and tenders must be sent to the Chairman of the Rivers Committee not later than Tuesday next, the 17th inst.

——— The Cardiff Corporation are prepared to receive tenders for the manufacture and delivery of electric light cables, &c., which must reach the Town Clerk on or before Monday next.

——— The Larne Town Commissioners will meet specially on Friday, the 20th inst., to consider any tenders that may be sent in for lighting the town for three years by gas or electricity.

Tenders Accepted.—The tender of Messrs. E. Houghton and Son, Stroud Green, N., has been accepted by the St. Pancras Vestry for the erection of new additional buildings to the electric light station in the Euston-road, the amount of the tender being £1,876. 4s.

Appointment.—The Kingston Town Council have appointed Mr. J. E. Edgcome resident engineer and manager at the electric lighting station, at a salary of £156.

Removal Notice.—Messrs. Lund Brothers and Co. have removed to 123 and 125, Oxford-street, W.

Liquidations.—Creditors of Abell's Electrical Engineering Company (Limited) are desired to send particulars of their claims to the liquidator, Mr. F. W. Marsh, Bank-chambers, Hardshaw-street, St. Helens, on or before November 15th.

——— A general meeting of Woodhouse and Rawson (Ltd.) is to be held in Room 434, at 11, Queen Victoria-street, E.C., on November 8th, at 4 p.m., for the purpose of passing an extraordinary resolution, directing as to the manner in which the books, accounts and documents of the Company, and of the liquidators, shall be disposed of.

——— A petition has been presented for the winding up of the Ipswich Electricity Supply Company (Limited), and is down for hearing on the 25th inst. at the Royal Courts of Justice, Strand.

Bankruptcy.—Under a receiving order granted on May 4th last against Knud Sando, described as a commission merchant, of 52, Wool Exchange, E.C., accounts have at length been submitted showing liabilities £32,944, of which £9,097 will probably rank, with assets £8,204. From the observations of the official receiver (Mr. A. H. Wildy), and the statements of the debtor, it appears that in 1879 he was in New Zealand as a partner in a firm of general merchants, and in that year the firm executed a deed of assignment for the benefit of creditors, who ultimately received a dividend of about 7s. in the pound. About five and a-half years ago he came to England to organise a company for colonisation purposes, and about a year later he began business, without capital, at 52, Wool Exchange, Coleman-street, E.C., as a general commission merchant, his business being chiefly the development and sale of patents and inventions. In December, 1890, the debtor states he began trading as a manufacturer of electrical appliances, which he carried on at Appold-street, E.C., and subsequently at Richmond, Surrey. In December, 1891, the Central Electrical Company (Limited) was registered, with the object of acquiring and carrying on the business last mentioned. The Company, however, did not go to allotment, and the debtor states he continued the business for his own account until February, 1892, when, having to go abroad on other matters, it was closed at a loss to him, as he estimates, of £3,000. He attributes his present insolvency to "losses in promoting the General Phosphate Corporation and loss of business through having to go to Canada in 1892 to assist this Company."

Dissolutions of Partnership.—The partnership between Charles Henry Freedman, Harrington Edward Hodson Wyman, and Frank West Suter, carrying on business as Frank Suter and Co., electrical engineers and contractors, of 66, Berners-street, has been dissolved, and the business will be in future carried on under the same name by the two last-named partners.

——— Messrs. Samuel Fynn and Charles Edward Stuart McCann, carrying on business as electrical engineers at 670, Commercial-road, E., have dissolved partnership, all debts to and from the late firm being paid by the former.

Incandescence Lamps.—The Edison-Swan Company announce a reduction in the price of their extra special lamps, in addition to that of their ordinary and special lamps, particulars of which appear in our advertisement pages.

Electric Lamps for Policemen.—Trial is being made at Dundee of an electric lamp constructed for the use of policemen, and the result of the experiment seems likely to lead to the old oil lamp being superseded by its modern rival.

Messrs. Paterson and Cooper.—We learn that this firm, who have been for several years on the Admiralty List for general fittings, have now been placed on their list for dynamos.

Messrs. J. G. Statter and Co.—We are informed that this firm have secured the contract for the electric lighting of the Royal Exchange.

Messrs. Nalder Bros. and Co.—This firm request us to state, with reference to a "Trade Note" in last week's issue, that their friend, Mr. N. F. Nalder, has never had any business connection with them.

Congdon *v.* Sambidge and Sons.—This case was heard this week at the Westminster County Court before Judge Lumley-Smith and a jury, and was brought to recover damages for breach of contract. The defendants were the well-known manufacturers of gas and electric light fittings at Birmingham, and the plaintiff was appointed

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to act as their London agent. He said that he was insufficiently supplied with samples of the defendants' goods, and had been unable to obtain repeat orders for them on account of inferior manufacture, and was therefore compelled to put an end to the arrangement. The defendants generally traversed the plaintiff's evidence, and after hearing counsel and witnesses on both sides the jury found for the defendants with costs.

THE METRIC SYSTEM IN THE UNITED STATES.—As an indication of the growing favour of the metric weights and measures in the United States, it is interesting to note that at a meeting of the Board of Managers of Engineering Societies, recently held in Chicago, it was resolved that illustrations, to be drawn to scale, should bear the metric scales.

FORTHCOMING SCIENTIFIC BOOKS.—The following books are announced by Messrs. Macmillan and Co. :—"The Theory of Heat," by Thomas Preston, with illustrations ; "Researches on the Propagation of Electrical Force," by Prof. Heinrich Hertz, of Bonn, authorised translation by Prof. D. E. Jones, with preface by Lord Kelvin, P.R.S., illustrated ; "A Text-book on Electro-Magnetism and the Construction of Dynamos," by Dugald C. Jackson, Professor of Electrical Engineering, University of Wisconsin. The Cambridge University Press announce : — "The Steam Engine and other Heat Engines," by J. A. Ewing, F.R.S , Professor of Mechanism and Applied Mechanics in the University of Cambridge. The Cambridge University Press are also about to publish a series of Natural Science Manuals which will cover a wide field, some of the books being adapted for beginners, whilst others will deal with special topics, and will be useful only to more advanced students. The series will be divided into two sections, a Biological and a Physical. The volumes of the Physical Series already arranged for include three by Mr. R. T. Glazebrook, F.R.S., Assistant Director of the Cavendish Laboratory, on "Light and Heat," "Electricity and Magnetism," and "Mechanics and Hydrostatics" ; these will be elementary text-books, based on the Practical Courses of Physics for Medical Students at the Cavendish Laboratory, The volume on "Light and Heat" is in the Press, and the other volumes are in preparation. Messrs. Charles Griffin and Co.'s announcements include :—"A Text-book of Physics : including Properties of Matter, Heat, Sound, and Light, Magnetism and Electricity," by Dr. J. H. Poynting, F.R.S., Professor of Physics in the Mason College, Birmingham, and J. J. Thomson, F.R.S., Professor of Experimental Physics in the University of Cambridge ; "Gas, Oil and Air Engines : A Practical Text-book on Internal Combustion Motors without Boiler," by Bryan Donkin, with illustrations ; "Engineering Drawing and Design : A Practical Manual for Engineering Students," by Sidney H. Wells, Principal, Battersea Polytechnic Institute, late of Dulwich College ; "Applied Mechanics (An Advanced Text-book of)," by Prof. Jamieson, Glasgow and West of Scotland Technical College, with very numerous illustrations. Messrs. Crosby Lockwood and Sons have in preparation and in the press :—"The Practical Engineer's Year-book for 1894, comprising Modern Engineering Formulæ, Rules, Tables, and Memoranda, in Civil, Mechanical, Electrical, Marine, and Mine Engineering," by H. R. Kempe ; "Tramways : Their Construction and Working, embracing a Comprehensive History of the System, with an exhaustive Analysis of the various Modes of Traction, a description of Rolling Stock, and details of Cost and Working Expenses" (with plates and other illustrations), by D. K. Clark, new edition, in one volume, rewritten and revised. "The Electrician" Printing and Publishing Company will publish Mr. G. S. Ram's book on "The Incandescent Lamp and its Manufacture" early next month.

"INTENSE BLACK" INDIAN INK.—We have received from Messrs. George J. Poore and Co., of Liverpool, a bottle of their "intense black" Indian ink, which we find runs freely, dries quickly, and is quite indelible. This ink seems admirably suited for drawings for reproduction by line "process" blocks.

BERWICK.—The electric light is being introduced into the border borough by several of the local tradesmen, who are fitting up private installations.

BO'NESS.—At a meeting of the Bo'ness Dock Commissioners last week the question of the electric lighting at the dock came up again on a motion that the finding come to at a recent meeting of the Commissioners against the introduction of the electric light on the ground of expense should be rescinded. The motion was, however, lost.

DUNDEE.—Messrs. William Fergusson and Sons, of Dudhope Works, North Tay-street, when considering the plans for the rebuilding of their burnt-down premises, decided to introduce the electric light, and the plant has just been installed by Messrs. Lowdon Bros., working from specifications drawn up by Messrs. Urquhart and Small. The dynamo is driven by a double cylinder compound vertical engine, made by Messrs. G. E. Belliss and Co., Birmingham, and indicating about 70 H.P. It is coupled direct to an Elwell-Parker dynamo running 320 revolutions a minute, and capable of lighting 700 lamps of 16 c.p. each. The current is led from the dynamo to the main switchboard on the wall of the engine-room. On the switchboard is an automatic cut-in, so that if by any mischance the main circuit should become disconnected, or the engine and dynamo be stopped, a number of lights would be instantly turned on in each department from the Corporation circuit. The Corporation circuit will also be in use before and after the work starts, when only a small number of lights is necessary. The switching-off of the main current in itself automatically turns on the Corporation circuit.——The demand for the electric light from the Corporation supply has been steadily increasing since the works were completed. Of the 6,000 lamps which the present power can supply, some 4,000 have been applied for, and are now being supplied, and it is expected that the remainder will soon be in use.

EDINBURGH.—Messrs. A. Whitelaw and Son, electrical engineers machine makers and general engineers, of Edinburgh, have introduced electricity into their works for lighting purposes with great success. Hand lamps have been fitted up in such a manner that they can be moved about from place to place to suit the convenience of the workmen. A Tangye 8-H.P. gas engine, used for running the machinery in the works, drives the dynamo, which is of special construction, manufactured by the Messrs. Whitelaw. It is calculated that the new light, allowing for interest on capital expenditure, will cost less than the same number of gas burners, whilst the light is, of course, immensely superior.——The Corporation have purchased a site in Dewar-street as a central station for the installation of electric light about to be introduced into Edinburgh.

GLASGOW.—The Tramways Committee of the Corporation reported at the last meeting of the Town Council that they had resolved to ask Mr. Arnot, the city electrical engineer, to submit a statement showing the price at which the electrical energy could be supplied to batteries for the electric haulage of the cars, and also the cost of laying down and superintending the dynamos and other plant required for charging the batteries from five of the car depots now being erected by the Corporation. The minutes were adopted.

HANLEY.—The Town Council at their last meeting empowered the General Purposes Committee to obtain separate tenders for the electric light wiring and fittings required in all the buildings of the Corporation, and to make application to the Local Government Board for permission to borrow the money required for such work. Under the Council's contract with the Brush Company, the Corporation had the option of determining within twelve months of the date of the contract whether the Company should provide the fourth set of generating plant, viz., boiler, engine, and dynamo, at a cost of £1,800, or expend that amount in electric light, street mains, and appurtenances at the scheduled prices named in the contract ; and the Council have decided on the latter alternative.

KILLARNEY.—The question of the public lighting still remains unsettled. It will be remembered that the gas lessees and the electric light company recently tendered for the lighting of the town, the former at £92. 10s., and the latter at £55, and a majority of the Commissioners gave the contract to the gas people, notwithstanding the difference between the tenders. The electric light company allege informality in the proceedings, and have served a notice on the Town Clerk and the Commissioners' solicitor, cautioning them not to perfect the contract for the gas. They have also served notices on two of the Commissioners to refrain from voting on the lighting question, they being shareholders in the gas company. Since the service of these notices the Commissioners have not met in sufficient numbers to form a quorum, although meetings have been called two or three times.

LIVERPOOL.—The Water Committee of the Corporation have decided to recommend the City Council to approve a supplementary estimate of £1,000 to provide telephonic communication and other electrical appliances between Liverpool and Lake Vyrnwy, and between Liverpool and the Rivington Reservoir.

LLANDRINDOD WELLS.—At a special meeting of the Local Board, on Friday, a discussion took place on the subject of introducing electric light to the district, and, at the request of the Board, the Clerk gave an account of the system adopted at Dolgelly, North Wales, which he had lately seen in operation. It was generally considered very desirable that steps should be taken to introduce the system, if possible.

LYTHAM.—A scheme for the electric lighting of Lytham has been laid before the Improvement Commissioners by Mr. J. Harding, C.E., but the Commissioners have decided to take no action in the matter.

NANTWICH.—The Local Board have had under consideration the question of increasing the number of electric lamps they use ; but although the contractor who supplies the current offered to increase

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it five-fold at little more than the present cost, the Board were afraid this might be only the thin end of the wedge, and would probably lead to the formation of another gigantic monopoly, and so resolved to remain illuminated by one lamp instead of increasing the number to five.

NORMANTON.—The Local Board having failed to obtain from the gas company more reasonable terms for the gas consumed by the public lamps, a committee has been appointed to inquire into and report on the best method and the cost of lighting the town by electricity.

RADCLIFFE.—The Local Board have appointed a Sub-Committee to consider the question of adopting the electric light in the district.

SOUTHWARK.—The St. Olave's Board of Works have decided to have their new offices lighted by electricity.

SUNDERLAND.—The Borough Surveyor has received instructions from the Highways Committee of the Corporation to advertise for tenders for laying the outdoor plant in connection with the electric lighting scheme.

WHITEHAVEN.—At the last meeting of the Town Council and Harbour Trust, the seal of the Board was affixed to a bond for £800, which was lent on account of the Electric Lighting Order by a private individual for six years at 3½ per cent.

YEADON.—A meeting of owners and ratepayers of Yeadon, convened by the Local Board, held on Tuesday, in the Town Hall, passed a resolution authorising the Local Board to adopt a system of electric lighting for the township.

COMPANIES' MEETINGS AND REPORTS.

Brazilian Submarine Telegraph Company (Limited)

The following is the report of the Directors for the half-year ended June 30, 1893, to be submitted to the fortieth ordinary general meeting, to be held in Room 174, Winchester House, E.C , on Wednesday next, October 18th, at 12 noon :—

The revenue for the half-year ended June 30, 1893, amounted to £106,859. 18s. 2d., and the working expenses to £40,580. 1s. 5d. After providing £12,880 for debenture interest and sinking funds, and £1,367. 8s. 1d. for income-tax, there remains a balance of £52,032. 8s. 8d. ; to this is added the sum of £4,000. 18s. 1d. brought forward from December 31st last, making a total of £56,033. 6s. 9d. A quarterly interim dividend, amounting to £19,500, has been paid, and £7,000 transferred to the reserve fund, increasing that fund to £638,675. 8s. 6d. The Directors now recommend the declaration of a final dividend of 3s. per share, making, with the interim dividends, a total dividend of 6 per cent. for the year, and also the payment of a bonus of 1s. per share, both free of income-tax, which together will amount to £26,000, leaving a balance of £3,533. 6s. 9d. to be carried forward. The dividend and bonus will be payable on the 19th inst.

On July 31st last the sum of £17,700 was transferred to pay off the 177 bonds of the 1884 issue, drawn for redemption in April last. This repayment reduces the debenture debt to £93,700.

The receipts for the half-year include the sum of £1,500 dividend to December 31, 1892, on the Company's shares in the African Direct Telegraph Company (Limited).

The Directors, with much regret, have to report the death, on May 7th last, of their esteemed colleague, Sir James Anderson. At the invitation of the Directors, Sir John Pender, G.C.M.G., M.P., has joined the Board, and accepted the Chairmanship of the Company.

Under a contract dated June 17, 1893, between the Portuguese Government and the Telegraph Construction and Maintenance Company (Limited), the Eastern Telegraph Company (Limited) and this Company are entitled to a prolongation for ten years of their respective privileges under existing Portuguese concessions. By arrangement with the companies concerned your Company has secured a considerable interest in the cable recently laid between Lisbon and the Azores under that contract.

The various sections of the Company's line are in good working order.

Mr. J. Denison Pender and Mr. Frederick Youle retire at this meeting, and being eligible for re-election as Directors offer themselves accordingly. The retiring auditors, Mr. Henry Dever and Mr. John Gane, desire to offer their respective firms, Messrs. Deloitte, Dever, Griffiths and Co., and Messrs. Gane, Jackson and Jefferys, for election as auditors to the Company.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1893, pages 320-348, *&c., &c.*]

SWAN AND HARRISON SMELTING COMPANY (LIMITED).—This Company was registered on October 3rd, with a capital of £30,000, in £5 shares, to acquire, take over as a going concern, and carry on the Roma Smelting Works, situate at La Union, near Carthagena, in Spain, now carried on by Arthur Harrison. The subscribers include J. W. Swan, Lauriston, Bromley, Kent, electrical engineer.

BABCOCK AND WILCOX (LIMITED).—The annual return of this Company, made up to September 13th, has been filed. The whole nominal capital of £240,000, divided into 10,000 £6 per Cent. Cumulative Preference and 14,000 Ordinary shares, of £10 each, has been subscribed for and allotted. Of this, 3,333 Preference and 4,666 Ordinary shares were issued as fully paid, while upon the remaining 6,667 Preference and 9,334 Ordinary the full amount has been called and £160,010 paid.

BICKLE AND CO. (LIMITED).—The first annual return of this Company, made up to September 20th, has been filed. Out of a nominal capital of £50,000, in £10 shares, 2,021 have been taken up, of which 1,000 were allotted to the vendors as fully paid. Upon the remaining 1,021 shares the full amount has been called, resulting in the payment of £10,050, leaving £160 unpaid.

CHILI TELEPHONE COMPANY (LIMITED).—The annual return of this Company, made up to August 16th, and recently filed, shows that 44,000 of the 50,000 shares of £5 each have been taken up, the full amount called, and all calls paid.

CHLORIDE ELECTRICAL STORAGE SYNDICATE (LIMITED).—The annual return of this Company, made up to July 28th, has been filed. The nominal capital is £262,500, divided into 110,000 "A," 140,000 "B," and 12,500 Founders' shares of £1 each. 65,230 "A," 100,000 "B," and 12,500 Founders' shares have been taken up, of which 45,000 "A," 100,000 "B," and all the Founders' shares were allotted as fully paid to the vendors. The full amount has been called and paid on the remaining 20,230 "A" shares.

COLUMN PRINTING TELEGRAPH SYNDICATE (LIMITED).—The recently-filed return of this undertaking shows that out of a nominal capital of £25,000, divided into 500 shares of £50 each, 229 have been taken up, of which 100 are considered as fully paid. Upon the remaining 129 shares the full amount has been called, resulting in a payment of £5,550, while £900 is still in arrears.

CITY NOTES, &c.

A. U. ALCOCK ELECTRIC LIGHT AND MOTIVE POWER COMPANY (LIMITED.)—The seventh half-yearly meeting of this Company was held at the offices, Russell-street, Melbourne, on August 31st. Mr. W. J. Mountain presided. The Directors' report showed that the revenue for the last six months, compared with that for the corresponding period last year, showed an average increase of over £150 monthly, while the working expenses had been reduced by over £102 per month. The profit made during the last 10 months amounted to £289, which was considered highly satisfactory, as that period embraced the summer months, when the demand for current was lightest. The Chairman in referring to the Company's position and the depression, said that it was highly satisfactory to note that the revenue had improved steadily, and had doubled since 1889, as it now amounted to £851. 18s. 2d. In 1889 the profit was only £111, and this year it had reached £289. During the period under review the machinery was continually working throughout the 24 hours of each day and in consequence the Company's profits were nearly trebled, and the public could secure a supply of current at any hour of the day. This latter factor, together with the meter system, had done much to popularise the use of the electric light. With an increased output the efficiency of the central station had improved, as better results were obtained from the quantity of fuel consumed. Thus, although the output was increased 43 per cent., the consumption of coal only increased 28 per cent. These results, however, were only being obtained by practising strict economy and improving the efficiency of the machinery wherever possible. The demand for light had been more than was expected since July 1st, and the custom had increased to the extent of 649 16-c.p. lamps, with prospects of many more being added during the next few months. The Directors' report was adopted, and Mr. Simon Fraser, M.L.C., and Mr. A. U. Alcock were re-elected Directors.

BRITISH VOLTA ELECTRIC GLOW-LAMP COMPANY (LIMITED).—A prospectus has been issued this week, offering for subscription 1,600 out of a total of 2,000 shares of £1 each, the remaining 400 being issued to the vendors as fully paid. The prospectus states that the object of the Company is to make and supply cheap and good incandescent lamps, works for their manufacture being about to be established near London. The Directors anticipate that, even when selling good lamps at an average price of 1s. each, a dividend of over 30 per cent. would be earned on the subscribed capital.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended October 8th were £813, as against £859 for the corresponding period of last year, being an decrease of £46. The total receipts for the half-year amount to £11,262, against £10,853 in the corresponding period of 1892, being an increase of £409.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The Board have resolved upon the payment of an interim dividend of 3s. 6d. per share, free of income-tax, being at the rate of 3½ per cent. per annum, for the quarter ended September 30, 1893, such dividend to be payable on and after the 24th instant.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this Company for September amounted to £23,600, and from January 1st to September 30th to £203,600. In the corresponding months of 1891 and 1892 the amounts were £213,400 and £199,600 respectively.

RICHMOND (SURREY) ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—We are requested to announce that this Company went to allotment on the 10th inst.

SUBMARINE CABLES TRUST.—Notice is given that on and after October 16th, the sum of £1. 15s., on account of the coupon due

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October 15, 1893, will be paid by Messrs. Glyn, Mills and Co., of 67, Lombard-street, between the hours of 10 a.m. and 2 p.m. The coupons should be left with the bankers for examination four clear days before payment.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended October 6, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,435.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 4.		Price Wednesday, Oct. 11.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 11.	
								£ s. d.		Highest	Lowest
			TELEGRAPHS								
£1,134,640	Stock	12/6	Anglo-American	50	51	49½	50½	5 8 11	Jan., Apr., July, Oct.	50	..
£2,932,680	Stock	25/0	Do. Preferred	92	93	92	9[illegible]	5 18 3	" "	93½	92½
£2,932,680	Stock	5/0	Do. Deferred	9½	9¾	9	9½	..	.. ..	9⅝	9⅜
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	99	102	99	102	3 18 5	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11½	12	11¾	12½	5 8 4	Mar., June, Oct., Dec.	12	11¾
£36,400	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107	111	107	111	4 10 1	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	135	140	135	140	5 0 0	April and October	..	..
16,000	10	8/0	Cuba Submarine	11	12	11	12	6 13 4	February and August	11¾	..
6,000	10	10%	Do. Preference 10 per Cent.	18	19	18	19	5 5 3	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2½	3½	2½	3½	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	8½	9½	8½	9½	5 5 3	" "	9¼	..
60,710	20	3/6	Direct United States	11⅝	11¾	11¾	12	5 16 8	Jan., Apr., July, Oct.	12	11¾
400,000	10	5/6	Eastern	15	15½	15	15½	4 5 3	" "	15½	15⅛
70,000	10	6%	Do. 6 per Cent. Preference	16	16½	16	16½	3 12 9	" "	16¼	16⅛
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112	115	113	116	3 9 0	May and November	116⅜	116
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	106	109	107	110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension	15½	15½	15½	15½	4 10 4	Jan., Apr., July, Oct.	15½	15½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	111	114	112	115	3 16 2	February & August	113¾	113
£70 600	100	5%	Do. 5 p. c.(Austln. Gov. Sub.) Debs 1900	102	105	102	105	4 15 3	January and July	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb.,1900	101	104	101	104	4 16 2	" "	103½	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909(regd.)	101	104	101	104	3 16 11	February & August	103½	..
£200,000	£25	..	Do. 4% Mauritius Sub. Debs.	103⅞	106⅞	104⅞	107⅞	..	May and November	105⅛	105⅛
180,227	10	4/0	Globe Telegraph and Trust	9⅜	9¾	9⅜	9¾	4 13 8	Jan., Apr., July, Oct.	9¾	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	15½	15⅝	15½	15⅝	3 17 5	" "	15⅝	15½
150,000	10	5/0	Great Northern	20	20½	20	20½	4 3 0	Jan., April, and July	..	..
£100,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	103	106	103	106	4 14 4	March & September	104¾	..
17,000	25	37/6	Indo-European	39	42	39	42	5 19 1	May and November	40½	40
37,548	10	4/0	London Platino-Brazilian	4	6	4	6	3 6 8	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh.4% Guar. Debs. "Red" 1942	101	104	101	104	3 16 11	.. ..	..	..
11,802	8	4/0	Reuter's	4½	5½	5	6	..	April and October	..	..
3,381	£100 Cert.	30/0	Submarine Cables Trust 6 per Cent.	116	121	116	121	4 19 2	" "	..	..
15,609	10	5/0	West African Telegraph	5½	6½	5½	6½	7 13 10	January and July	..	..
£260,900	100	5%	Do. 5 per Cent. Debentures	98	101	98	101	4 19 0	March & September	..	..
30,000	10	2/0	West Coast of America	2	3	2	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	98	102	98	102	7 16 10	June and December	..	..
88,321	10	6d.	West India and Panama	1⅜	1⅝	1⅜	1⅝	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10 5/16	10
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9	10	9	10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	106	109	106	109	4 11 9	June and December	..	..
64,242	15	4/6	Western and Brazilian	6½	7	6¾	7	5 7 6	May and November	7	6¾
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5⅝	6½	5⅝	6½	..	..	6	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1	1½	1⅛	1¾	..	..	1½	1⅜
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 13 2	February & August	..	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	115	120	115	120	5 16 8	May and November	..	..
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	101	104	102	105	5 14 3	March & September	104¼	104
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	2	3	2	3	..	..	..	..
22,500	10,0	3½d.	Consolidated Telephone Const. & Maintenance	1/16	1/8	1/16	1/8	..	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/4	3/8	1/16	1/8	7 18 2	Yearly	1/4	..
458,867	5	2/6	National	4⅛	4⅜	4⅛	4⅜	5 2 7	June and December	4 1/16	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref	14	15	14	15	4 0 0	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	13½	14½	13½	14½	4 2 9	" "	14½	13⅝
90,950	5	2/0	Do. 5% Non-Cumulative 3rd Pref.	5⅛	5⅜	5⅛	5⅜	4 13 0	.. ..	5⅛	5⅛
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	112	114	112	114	3 18 11	January and July	113⅜	113¼
58,000	5	1/0	United River Plate	2	2¼	2	2¼	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	11½	11¾	11½	11¾	..	..	..	..
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12¾	13½	12¾	13½	..	..	13½	12¾
19,900	£5	..	Electricity Supply Co. for Spain	..		..		..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	..		..		..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	..	..	..
8,322	£5	..	House to House Electric	..		..		..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4⅛	4½	4½	4½	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6	6½	6⅝	6⅝	..	..	..	..
111,000	5	..	London Electric Supply	¾	1	¾	1	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6¾	7½	6¾	7½	2 15 2	..	..	..
£100,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	104	107	104	107	4 13 6	June and December	106½	106⅜
6,452	£10	..	Notting Hill Electric	5	6	5	6	..	..	..	..
19,980	£5	9½%	St. James' and Pall Mall	6½	6¾	6½	6¾	..	..	..	..
10,000	£5	7%	Do. 7 per Cent. Preference	8	8½	8	8½	4 2 4	..	8½	8⅜
59,900	5	1/6	Westminster Electric Supply (fully paid)	5	5½	5	5½	3 3 8	..	5½	5⅜
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	2/1	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	..	3	2¾
75,000	2	6%	Do. 6 per Cent. Preference	2⅞	2⅝	2⅞	2⅝	5 1 1	..	2⅝	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107	109	107	109	4 2 7	March & September	108	..
20,000	5	2 6	Crompton and Co., 7 per Cent. Cumulative Pref.	3½	4½	3½	4½	..	January and July	..	..
12,139	5	..	Edison and Swan United	..		..		..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	..	..
49,900	10	12/0	Electric Construction	1½	2	1⅝	2¼	..	..	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜	⅝	⅜	⅝	..	..	⅜	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1½	1¾	1½	1¾	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½	22½	21½	22½	5 11 1	February & August	23⅛	21½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	101	103	101	103	4 7 5	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	1	2	1	2	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	..		..		..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/0	4/0	3/0	4/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	2	2½	2	2½	13 19 8	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	32	34	31	33	5 9 1	March and July	32½	32
£150,000	100	5%	Do. 5 per Cent. Bonds, red.1894	101	104	101	104	4 16 2	January and July	103	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	..		..		..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	¾%	City and South London Railway	30	35	30	35	2 2 6	May and November	..	..
37,500	£10	..	Liverpool Overhead Railway	5½	5½	5⅜	5⅝	..	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 805.—Vol. XXXI. FRIDAY, OCTOBER 20, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

We greatly regret to learn that Prof. Von Helmholtz, after escaping unhurt from riots, fire, railway accidents, tornadoes, and other perils incident to a visit to Chicago, met with a rather serious accident on board the steamship "Saale" during his return voyage. He fell down a companion ladder, and sustained injuries to his head. He was conveyed to the town hospital at Bremen on his arrival. His wife and daughter were with him. The condition of Prof. Von Helmholtz, the *Standard's* Berlin correspondent telegraphs, was somewhat better on Wednesday, but much rest and great care in nursing will be required before the eminent *savant* can be restored to his usual health. In reply to our inquiries yesterday afternoon we learned by telegraph from Dr. Goering, of Bremen, and from Charlottenburg, that Prof. Von Helmholtz is better.

In congratulating the inhabitants of Blackpool on their advanced municipal politics, Lord Kelvin, inaugurating the new supply station and public lighting, recommended that municipal corporations should take into their own hands everything which they could do efficiently for the good of the town, but they should not enter into transactions with distant places. Telephones and railways, he thought, should be acquired by the Government; but, for another reason, namely, that that which private companies could not do well, because of conflicting interests, was best done by the State. These two reasons might easily be exchanged; they have nothing in common with each other; and either they are no real reasons, or they may both be applied together. If Socialism is to come it does not matter much about reasons, but when the manufacturers and merchants, who have by their individual enterprise built up the commercial fortunes of this country, are invited to become vestry officials or Government clerks it will be time enough for them to consider whether it is a country worth living in. A further question, which may come too late, will be—Can the country get on without them? How long would telegraphs have been delayed if it had remained for the Government to start them, especially when an official statement was made in reply to an offer of an electric telegraph, that no improvement on the semaphore was wanted?

The daily papers have been discussing the "cheapening of electric light" in consequence of the reduction of the price of lamps. Prof. Ayrton has clearly shown in his recent article in these columns that, indirectly the smaller cost of the lamp allows a further economy by making it worth while to run at a higher efficiency. Experience alone can show to what extent lamps can thus be over-run, to use a common but not accurate expression. It is no doubt true that a 97-volt 6½-c.p. lamp on a 100-volt circuit will give about 8 c.p., and a 97-volt 13-c.p. lamp will give about 16 c.p. at first, but it is probable that the deterioration will be more rapid, and that the economy will therefore be somewhat reduced. Neglecting this over-running for the present, we give below a simple statement of the effect of reducing the price of lamps from 3s. 9d. to 1s. 6d., assuming that the life, as heretofore, will be about 1,000 hours, and that an 8-c.p. lamp consumes one supply unit in 30 hours.

Price of a supply unit.	Cost of supply for 1,000 hours.	Total cost.		Reduction per cent.
		Lamps at 3s. 9d.	Lamps at 1s. 6d.	
8d.	22s.	25s. 9d.	23s. 6d.	8·8
6d.	16s. 8d.	20s. 5d.	18s. 2d.	11·0
4d.	11s.	14s. 9d.	12s. 6d.	15·2

This is equivalent to a reduction in the price of supply to 7⅓d., 5⅓d., and 3·4d. respectively.

In another column will be found extracts from *The Times* on the subject of the subsidising by the Queensland and New South Wales Governments of the submarine telegraph cable just completed from Queensland to New Caledonia by the Société Générale des Téléphones, of Paris. The action of these Colonies is greatly to be regretted, as being opposed to Colonial and Imperial interests, and as tending to retard the establishment in British hands of direct submarine telegraph communication between Australasia and North America. Sir George Dibbs' defence of the position taken up by the New South Wales Government is lame in the extreme; and is completely controverted by the Marquis of Ripon's letter on the subject. It should be pointed out that it is quite misleading to call the cable in question the first section of a Pacific Cable, because the Imperial Government and most of the Colonies interested would certainly not subsidise a line which would be, in the event of political complications arising, completely under French control.

We print, this week, an addendum to Lord Kelvin's British Association Papers on the Piezo-electric effect in

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crystals and at the contact of dissimilar metals. The Papers deal with an electrification due to pressure, or, rather, to unequally-distributed stress. In the dielectric crystal all that is necessary is a certain space variation of stress; but, as pointed out by Prof. FITZGERALD in the discussion on the two Papers, this is not sufficient to produce the effect in a system of dissimilar conductors. For the latter, owing to the gradual distribution of an equalised potential on account of conductivity, will require both a space variation and a time variation also. It is interesting, probably only from a theoretical point of view, to discover that the analogue of a thermo-pile can be constructed with, not difference of temperature between the junctions, but differences in the time rate of variation of the pressures at those junctions.

SOME curious experiments upon glow lamps have been described to us by Mr. A. A. C. SWINTON. By means of a high-frequency alternator, and a condenser formed out of a thick plate of glass and a couple of wire-ends, it was possible to raise an ordinary 100-volt glow lamp to full incandescence. The explanation which Mr. SWINTON offers is that the current consists of very brief intervals of enormous current alternating with longer intervals of practically no current. He observes that with a steady pressure of 100 volts the 5-c.p. lamp would expend 25 joules in every second, at a steady rate of 25 watts. With a high-frequency current of 100,000 $\sim$ per second, and 10,000 volts, it is clear that each pulsation would be required to produce 0·00025 joule, and to pass only 0·000000025 coulomb, in order to develop the same energy per second. The average current in the lamp during any one impulse would be as great as 25 amperes; but each impulse would be followed by a period of inactivity 999 times as long, making the average current in the complete second only 0·0025 ampere. The thermal capacity of the filament would prevent its temperature varying in the same ratio as the extremely variable power, and would cause it to emit a practically steady light. In the same way, for example, we might apply a transient force of many millions of pounds to the rim of a flywheel, while causing it to turn only with the normal speed which a steady force of a hundred pounds would produce.

THE explanation previously put forward by Mr. SWINTON, and we believe at an earlier date by Mr. SWINBURNE, was that the inductance of the current elements in the filament on one another is, with very high-frequency pressures, so enormous that the current flows entirely through only the outermost skin of the conductor. The effective resistance of the filament might in this way be raised many hundreds of times above its steady value. The advantages of this explanation are, chiefly, that it does not require that the current-impulses shall be interrupted by such long periods of inactivity, for the same effect might occur with a sufficiently frequent simple harmonic pressure, and it does not require so great an instantaneous value of the current. But Mr. RIMINGTON has calculated the increase of resistance, and finds that the frequency would have to be enormous. If there is no skin effect it is difficult to see how 25 amperes can be passed through the human body, although it is said that a very much greater number of amperes is produced at the instant of some Leyden jar discharges which are not physiologically injurious. It seems probable that the true explanation of the phenomenon is to be found in a combination of the two hypotheses: that on the one hand the curve representing the current variation would show moments of strong activity followed by longer intervals of very much smaller current, while, on the other hand, the inductance of current-elements on one another would cause a perceptible skin-effect and increase the resistance of every part of the circuit.

A WRITER in an esteemed scientific contemporary, signing himself "J. S.," points out, as we have pointed out more than once, that OHM's law of the resistance of a circuit is something more than a mere definition of electrical resistance. The expression $C = E/R$ represents, he says, a physical fact; namely, the fact that "the resistance of a circuit is constant as long as its physical conditions, such as temperature and linear dimensions, remained undisturbed." This we readily admit to be the proper intrepretation of the law; but we believe that, not only was OHM unable to demonstrate the truth of this, but quite failed as a necessity to grasp the fact that the law was a purely experimental result, the truth of which no one could have predicted. Such a generalisation as OHM's law which "J. S." propounds must rank with NEWTON's generalisations on gravitation, and can only be permitted when a large mass of experimental evidence from all sorts and conditions of conductors points in the direction of its validity. It is an induction which it would be highly dangerous to base upon experiments made only on a few feet of copper and iron wire of assorted gauges.

OUR selections from Mr. G. S. RAM's book on "The Incandescent Lamp and its Manufacture" are concluded this week. We should have made further extracts had time permitted, since the articles have, we believe, interested many of our readers who have no intention of concerning themselves with lamp-making, but who wish to know something of an important industry which has hitherto been kept strictly secret, and on which nothing has been written since Mr. J. SWINBURNE's series of articles in *The Electrician* in 1887. The book will be published early next month.

THE impudent announcement of the issue of new shares in the Medical Battery Company by HARNESS serves to show how a cunning impostor may flourish if he can elude the letter of the law. Having lost, or settled by payment of considerable sums, every law-suit in which endeavours have been made to expose his doings, he yet managed to keep out of Court all the mass of evidence which had been carefully collected. Actions for obtaining money under false pretences, for libel, or prosecutions by any medical association, are all beside the mark. We have more than once urged that a Treasury prosecution should be instituted, which should result in the stamping out of that which was characterised before Lord Chief Justice COLERIDGE as an "abominable system of imposture." A vigorous article in the *Pall Mall Gazette* of yesterday denounces HARNESS and his Company, and promises in future issues to publish some of the evidence to which we have alluded.

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Cable Interruptions and Repairs.—There are no cable interruptions to record this week.

The Telephone in Scandinavia.—One of the longest telephonic communications in Europe was recently opened between Christiana and Stockholm. The distance between the two cities is about 250 miles.

The Institution of Electrical Engineers.—The annual dinner of the Institution of Electrical Engineers has been arranged for Wednesday, November 22nd, and will take place at the Freemasons' Tavern, Great Queen-street.

The Mashonaland Telegraph Lines.—Telegraphic communication between Cape Town, Forts Victoria, Charter and Salisbury, which was interrupted on Tuesday and Wednesday of this week, has been completely restored.

Telephonic Communication between Barry and Cardiff.—A subsidiary line is in course of construction, and will be completed shortly, between Cardiff and Barry, in order to provide facilities to cope with the rapidly increasing volume of telephonic business at the post office at Berry Dock.

Fire at Finsbury Technical College.—A fire was discovered on Wednesday evening in the chemical lecture room of this college. Some damage was done to the lecture table and flooring, but the fire was quickly extinguished by the fire brigade, who, of course, attributed it to the "electric light." The cause is unknown.

Telephonic Communication with Lightships.—Instructions have been given for the immediate laying of cables between the shore and the Kentish Knock and North Goodwin Sands Lightships for telephonic communication, so that the work may be done before the winter sets in. The cable to the North Sands is to be landed at Dumpton Gap, Ramsgate, and the cable for the Kentish Knock at Kingsgate Bay.

Kingston-on-Thames.—The new electric light station at Kingston-on-Thames will be opened by the Mayor to-morrow. The town hall and other municipal buildings have been fitted with glow lamps, and among the largest of the private consumers will be the Surrey County Council, who are having their new buildings wired. Street lighting will be effected by means of 36 arc lamps, rated at 1,000 c.p. each. The generating plant has been built by Messrs. Siemens Bros. and Co.

Personal.—We understand that Mr. Joseph A. Jeckell, late Works Manager of the International Okonite Company, has been appointed Electrical Engineer to the Borough of South Shields.——Mr. Hylton Spagnoletti is about to sever, or has already severed, his connection with the National Telephone Company, after eight years of successfully piloting the Swansea branch of the late Western Counties and South Wales Telephone Company. Messrs. J. B. Saunders and Co., of Cardiff, have secured Mr. Spagnoletti's services as their agent in Swansea and district for electric light installations and private telephone work.

Great Storm in America.—The storm which recently visited the United States swept over a wide area. It was felt from the Gulf of Mexico along the coast to Maine, and reached westward as far as Buffalo. Telegraph wires were thrown down, delaying the reports of the damage done. At Baltimore two electric light wires became crossed in the tower of the Brush Electric Light Works, setting fire to the tower. Pieces of blazing wood were blown to the rafters of the gaol near by, where five hundred and forty-four prisoners were confined, and the building was burned down. The prisoners were rescued with difficulty, one man being killed and twenty injured. The loss to the Electric Company amounts to two hundred thousand dollars, and the burning of the gaol entails a loss of fifty-five thousand dollars.

Train Lighting.—The Directors of the London, Brighton and South Coast Railway have given instructions for the equipment of ten more trains with the electric light. This will make a total of 40 trains so fitted. We understand that the superiority of this method of lighting is very marked, and affords much satisfaction to those working the traffic. Especially is the benefit felt in busy times and foggy weather, when under ordinary circumstances gas-lighted trains would have to be sent specially to the charging stations or put out of working altogether. It is estimated that at least 15 per cent. more work is got out of electrically-lighted trains than gas-lighted trains for the above-mentioned reasons. This simply, in the construction of say 100 trains, would mean a saving of something like £45,000 in first cost, *i.e.*, 85 electrically-lighted trains would do the work of 100 gas-lighted trains.

Canadian Electrical Association.—The third Convention of the Canadian Electrical Association was, says the *Canadian Electrical News*, in every way a success. The Papers were of a high order, and gave rise to interesting and valuable discussions. By means of Papers such as the one presented by Mr. McFarlane the Association will be the means of collecting much interesting data concerning the early history of electrical matters in Canada which might otherwise be lost, and which will form a valuable record in years to come. The Association was fortunate in having present at this Convention, not only members from all parts of Ontario and a good delegation from Quebec, but also representatives of the North-west Territories and British Columbia. Next year, when the Convention will be held in Montreal, it is hoped that Nova Scotia and New Brunswick will also be represented. The decision to have the next Convention in Montreal will no doubt tend to give the Association a more cosmopolitan character. The steady increase in membership is a gratifying sign of progress.

Fog Signalling by Electricity.—The Great Northern Railway Company have been extending, on their North London branches, the experiment of fog signalling by means of electricity. The method of working is very simple, and is the invention of an electrician in the employ of the Great Northern Railway Company. A wire is laid, by means of a pipe, from the signal-box to the various signals, at which points brushes, composed of copper wire, project some 4in. or 5in. above the side of the rail nearest the signal. To the foot-plate of the engine a similar brush is fixed, connecting with an indicator and bell on the engine. If the signal be at danger the two brushes coming in contact has the effect of ringing the bell and indicating to the driver, by means of a miniature signal fixed on his engine, that the line is not clear. The arrangement can be switched off in fine weather. The process, which is in working order at Wood Green, has proved so satisfactory that the Company, it is said, have decided to fit up the suburban lines, and eventually the whole of their system.

Extension of the Electric Lighting of Glasgow.—The station which the Corporation erected in Waterloo-street to meet the wants of the central area of the city was equipped at the outset with machinery which it was thought would suffice for several years at least. It consisted of seven Willans central-valve compound engines—two of 80 H.P., two of 150 H.P., and three of 250 H.P.—and an equal number of dynamos, two having an output of 400 amperes at 120 volts, two an output of 400 amperes at 230 volts, and three an output of 670 amperes at 230 volts. The applications for light for private premises have been so numerous that at present two new engines of about 850 I.H.P. each are being put down to light an equivalent of 14,000 8-c.p. incandescent lamps. Beyond this plant the station contains four dynamos for the arc lamps with which the streets are illuminated. The station was originally designed to supply 22,000 incandescent lamps. The new machinery, however, will increase the number to no fewer than 40,000. The current is used for the most part for lighting purposes, but in several cases it is being employed to drive motors and ventilating fans. The Municipal Buildings take the largest supply yet sent out, the lamps there being equivalent to 1,500 of 8 c.p. In the Post Office there are 1,000. The Theatre Royal has 1,160, the Clydesdale Bank 900, the Union Bank 744, and the Central Agency, Bothwell-street, 700. As matters are at present, the station cannot give any more light to private consumers, and in the meantime it has been decided not to consider any new applications. The station, in fact, has reached the limit of its load, the output on Friday being 4,340 amperes at 100 volts, which is equal to 13,000 8-c.p. lamps actually lighted.

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ELECTROMAGNETIC THEORY.—LVI.

BY OLIVER HEAVISIDE.

(Continued from page 605.)

§ 215. We have now to consider in what way self-induction comes in to influence the transmission of waves along wires. The first step in this direction was made by Kirchhoff as long ago as 1858, but it is only in recent years that self-induction has become prominent as an active agent, and its real resultant effect worked out and understood. more or less. This effect is, on first acquaintance, a somewhat surprising and paradoxical one. Everyone knows the impeding effect of self-induction in apparatus. How, then, in the name of Faraday, can it be beneficial in a telegraph or telephone circuit, and make signals bigger and clearer? It will be convenient to make use of an analogy in the first place.

There is, in a great measure, a formal resemblance between the problem of a telephone circuit along which electromagnetic disturbances are being propagated, and the mechanical problem of the transverse motions of a stretched flexible cord. But to make the formal resemblance be also a practical resemblance, several little things have to be attended to, and reservations made. Now there are a great many mechanical problems concerning wave-motion subject to friction which make better analogies for the use of the mathematical inquirer; but the case of a flexible cord is more or less familiar to everyone, and is, up to a certain point, easily realisable.

The commonest knowledge of the transverse motions of a stretched cord is concerning its normal vibrations, the fundamental mode and its harmonics. But we do not want them in our analogy. For although we may have something similar with short waves, and especially Hertzian waves, it would not be easy to set up such a state of things on a telegraph circuit, which is usually so long as to prevent the assumption of normal modes by reflection at the ends. For the normal vibrations of a cord are complex affairs, depending not only upon propagation of motion along it, but also on the constraints to which it is terminally or intermediately subjected. We desire the propagational effect to show itself distinctly. But if we disturb a stationary stretched wire at one end, the pulses produced run to and fro too quickly for practical observation. Take, then, a long india-rubber cord, suspended from a height, as is sometimes done by lecturers. The speed of transmission of pulses may be made small enough to allow the disturbances to be conveniently watched. Then, if the cord hang vertically at rest to begin with, and its lower end be momentarily jerked, bringing it immediately back to its original position, a hump is generated, which runs along to the fixed end. It is not much changed in transit, and is reflected back, and re-reflected many times. But we only want to consider the passage of a hump one way. Properly speaking, then, we should have so long a cord that reflection is (by frictional loss) insignificant. Perhaps a very long cord laid upon a surface of ice would be more suitable for the purpose. But if the "fixed end" be movable transversely, and its motion be resisted by a force proportional to its velocity, their constant ratio may have such a value given to it (depending upon the mass and tension of the cord), that the arriving disturbances do not produce any reflected waves, but are absorbed by the terminal resistance. The cord then behaves as if it were infinitely long. This is theory, of course, but I dare say a sufficiently good practical imitation could be got by means of a terminal block sliding upon a wire with friction. An imperfect cancellation of the reflection is easily got.

Disregarding the slow change of type and the attenuation, so that there is undistorted propagation of a hump, or of a succession of humps making a train of waves going one way only, this case is analogous to the transmission of waves along a uniform circuit of no resistance. The two constants L and S in the electrical case are replaced by another two, viz., the density (linear, or mass divided by length) and tension of the cord. Thus, large permittance, that is, small elastance, means small tension, or a slack cord; and large inductance means a massive cord. If I said a "heavy" cord, it might be thought that its weight was concerned in the matter in question, but it is not, save as a disturbing factor. The transverse displacement of the cord may be compared with the transverse voltage in the electrical circuit. Other comparisons (theoretically better) may be made, but this is perhaps the most convenient if the motion of humps be actually watched.

Now to imitate the action of the resistance (assumed to be constant) of an electrical circuit, the transverse motion of the cord must be frictionally resisted, and the frictionality (or coefficient of friction) should be constant. That is, the frictional force should be proportional to the transverse velocity. The motion of the cord is frictionally resisted, both internally and externally. It is very unlikely that this should give rise to a constant frictionality, but there is a similarity insofar as the waves sent along the cord do attenuate and are distorted as they progress.

But the friction is not anything like enough in the case of a cord in air to imitate the submarine cable; besides that, the mass is too great, and likewise the tension. Even to copy telephonic waves going along very long copper wires of low resistance, we should increase the friction in the mechanical analogue if we desire to have an equal amount of attenuation in a wave length. The cord should, therefore, be in a viscous medium, and the viscous resistance to the cord's motion should be so great as to produce a marked attenuation during the transit of a hump, though it should not be so great as to prevent its distinct propagation as a hump, without great distortion of shape and spreading out. Under these circumstances we may exemplify low-resistance, long-distance, overland telephony, where the inductance is relatively large and the permittance relatively small.

But to imitate a submarine cable we should have a slack cord of small mass in a highly viscous medium. We can then send a hump only a little way along it as a hump, for it becomes greatly distorted and diffused. Consequently, if we compared the displacements at a great distance along the cord with those impressed upon it at the free end, we should find a state of things quite different from what occurs in the case of an india-rubber cord in air. The main features of the originated disturbances might be recognised, unless the attenuation were too great, but they would be out of all proportion. In particular, there is a tendency to obliterate small humps, or ripples, whilst the big ones persist. The propagation is of the sluggish kind, characteristic of diffusion, quite unlike that of purely elastic waves. If the slack cord could have no mass at all, we should then imitate a submarine cable wholly without inductance.

Under these circumstances we could convert the diffusive waves to something like elastic waves by giving mass to the cord. Without changing either its tension or the frictionality, we could, by a continuous increase of density, cause the nature of propagation to pass continuously from the sluggish, diffusive kind to the elastic kind with approximate preservation of form of waves. We might also do the same by increasing the tension and reducing the frictionality (like, by reducing the permittance and the resistance in an electrical circuit, bringing the inductance into importance). But these are not immediately in question. By increasing the mass, or equivalently the inertia of the cord, we impart momentum to the waves, which allows them to be carried forward, in spite of the little tension, against the resistance of the surrounding medium.

So it is in the electrical case. By increasing the inductance we impart momentum to the waves, and that carries them on. This statement is independent of the particular mechanical analogy that may be employed for illustration. It is, probably, representative of the actual dynamics of the matter, associating L with inertia, and LC with momentum. The soundness of this dynamical explanation (made by me some years since in asserting and proving the fact concerned) was endorsed by Lord Kelvin. And I am proud to add, for the benefit of those who may excuse themselves from understanding me by the plea that I am a Schopenhauer (!), that Lord Kelvin expressed his appreciation of the very practical way in which I had reduced my theory to practice.

Many other dynamical arrangements might be alluded to, exemplifying the power of inertial momentum to overcome

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frictional resistance, but it is not easy to get a good one exhibiting elastic waves plainly.

To illustrate the nature, and to emphasise the possible magnitude of the effect, suppose we have the power of continuously increasing the inductance of an Atlantic cable from a small quantity up to a very large one, without altering its resistance or permittance, and without introducing any other actions than those to be controlled by resistance, permittance, and inductance. Starting with L = 0, and making, say, 1,000 waves per second at one end, there will be 1,000 waves per second of workable magnitude only in a small part of the cable near the sending end; the amplitude will attenuate to insignificance, not exactly in the shore-end, but before 100 miles is traversed. But let waves of the same size (which will need greater battery power to produce) be kept up at the sending end, whilst L is continuously increased all along the cable. The region of practical waves will continuously extend itself right through the cable, by a partial conversion to elastic waves, with little attenuation in transit. With very big inductance the waves would reach the distant end nearly in full size. Even then they could be doubled in size by the reflection, though there would be no useful purpose served by that. The amount of inductance required, however, to produce these results would be out of all reason. Nevertheless, the illustration serves its purpose in showing the action of self-induction, which is, as before stated, wholly beneficial, as it increases the amplitude and lessens the distortion. Some remarks on increasing inductance will come later.

§ 216. In the meantime, some few remarks on self-induction combined with leakage should come in here. Self-induction came in with the telephone. That was, originally, a mere house-to-house affair. At any rate, lines were only a few miles long. So condenser action was out of practical question then. On the other hand, the frequency of the currents concerned is very great, and that makes inertia important. So the theory of telephones is a magnetic affair when the lines are short enough, just as if they were lines in a laboratory.

But the telephone soon got beyond that, and it became necessary, with the use of longer and longer lines and underground lines, to examine the influence of their permittance in conjunction with their inductance. In hardly any case of telephony can we ignore the self-induction, and take the permittance alone. The resistance would need to be so large that the lines would be wholly unsuitable for telephony, except for mere local lines. So permittance and inductance usually go together in considering telephony, and if one of them is ignorable it is the permittance rather than the inductance.

Following the telephone came exchanges. But there was an exchange before telephones. My brother, Mr. A. W. Heaviside, had an intercommunication exchange at Newcastle, using alphabetical indicators, whereof the manipulation resembled that of the hurdy-gurdy. These were beautiful instruments mechanically; but, of course, the telephone soon stopped their manufacture. The exchange referred to was then turned into a telephone exchange. Now, in certain cases it was needed to have many instruments in one circuit, with local intercommunication; a sort of family arrangement, so to speak; for example, a number of coal pits and colliery offices belonging to one firm. The custom was to set all the intermediates in sequence (otherwise, but perhaps not so well, called in series) in the circuit. Why was this done? Simply because they knew no better. It was the custom to do so in the telegraphs generally, being an obvious arrangement—not so much in England, though, as elsewhere. But when this was done with telephones, or with call-instruments replacing them, it was found that the intermediates had a very deleterious influence, which very soon set a limit to the admissible number of intermediates on a circuit and to the length of the circuit, especially when underground wires were included. My brother, who took up the telephone with ardour from the first (making the first one made in England, I believe), found by experiment that it was quite unnecessary to put the instruments in sequence according to old practice, and that an immense improvement was made by taking them out of the circuit, and putting them across it, as shunts or bridges. Like lamps in parallel, in fact. It seems very easy and obvious now. But it is not so easy to conceive the state of mind of old stagers. Anyhow, the proposition to put the instruments in bridge was pooh-poohed at first, not being understood. As, however, it was demonstrably a wonderful improvement it was adopted, first at Newcastle, and then elsewhere, and became known as the Bridge System.

When this system was brought to my knowledge, and I was asked for theoretical explanation, it presented itself in a double aspect. First of all, there was the complete removal from the circuit of intermediate impedance in big lumps. This was manifestly the main reason of the increase in working distance possible, and why a far greater number of intermediates could be put on. For they were not put in the circuit, but on it, so to speak.

The other aspect of the matter was this. Considering that the bridge system consists electrically of a circuit with a number of leaks on it, and bearing in mind my old investigations concerning leaks, I inquired whether the intermediates were not actually beneficial to through communication, independently of the previous effect. Was not the articulation better, not merely than if the intermediates were in series in the circuit, but better than if the shunts or bridges were removed altogether, leaving insulation? My brother's answer was Yes, certainly, in certain cases, but doubtful in others. It appeared, however, to be only a minor effect, of not much importance compared with the major one. Besides, the bridges caused a weakening of the intensity of the speech received when many bridges were passed. To prevent this weakening becoming inconveniently great, the intermediate call-instruments in bridge were purposely made to have considerable resistance and inductance, far more than would be needed or desirable for their natural use. This tended to prevent the currents passing along the line from entering the shunts, and especially so as regards the currents of high frequency, and allowed them to be transmitted in greater magnitude.

It will be observed here that the expediting effect of leakage considered before (§§ 213, 214) is merely incidental, and is, in fact, partly destroyed by the large impedance of the bridges, in order to mitigate the attenuative evil. The shunts are inductive shunts, intentionally very much inductive. Now, my proposed leaks (§ 214) for submarine cables were non-inductive, and intentionally so, though it may be remarked that it would make very little difference with the slow signalling of Atlantic cables if they were inductive. On the other hand, a recent proposal of Prof. Silvanus Thompson is to use inductive shunts on cables. The arrangement is electrically as in the bridge system, but the object is different. This point will be returned to.

The investigation of this bridge system of telephony suggested to me the distortionless circuit, as I have before acknowledged ("Electrical Papers," Vol. II., p. 402). It may be of interest to state how it came about, since it is not presented to one by the above-described experiences with the bridge system. The question was, What was the effect of a bridge, or of a succession of bridges, when the self-induction of the line was not negligible? Now the influence of the bridges can be very readily stated for steady currents, of course. There is no difficulty, either, in finding the full formulæ required to express the voltage and current and their variations in any part of the system when the inductance and permittance are operative, as well as a set of leaks, when one knows how to do it. But the general formulæ thus obtained are altogether too complicated to be readily interpretable. I was, therefore, led to examine the effect produced by a leak on a wave passing it of the elastic type. This implies that the resistance of the line is sufficiently low for waves of the frequency concerned to retain that type approximately. (L*n* should be greater than R.) Now this was comparatively an easy problem, and the result was to show that a leak (or conductance in bridge) had the opposite effect on a wave passing it along the line to that of a resistance inserted in the circuit at the same place, in this sense:—A resistance in the circuit reflects the charge positively and the current negatively, or increases the charge and reduces the current behind the resistance. On the other hand, a leak reflects the current positively and the charge negatively, or increases the current and reduces the charge behind the leak. (*See* also §§ 197, 209.) A resistance and a leak

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together at the same place therefore tend to counteract one another in producing a reflected wave, leaving only an attenuating effect on the transmitted wave. This led to the distortionless circuit. For although the compensation of the resistance in the circuit and the conductance across it is imperfect when they are finite, it becomes perfect when they are infinitely small. They may then be a part of the circuit itself, namely, the resistance a part of the resistance of the line, and the conductance a part of the leakage. We now have perfect compensation with this one, or any number of successive resistances and leaks of the same kind, provided their ratio is properly chosen. This occurs when R and K, the resistance and conductance per unit length of circuit, of the line and of the leakage respectively, are taken in the same ratio as the two other constants, L and S. Or, when $L/R = S/K$, indicating equality of the electric and magnetic time-constants. There is now an undistorted transmission of any kind of signals. And since every circuit has R, L, and S, it follows that it can be made distortionless by the addition of leakage alone of a certain amount, or distortionless to the extent permitted by the approximate constancy of R, L, and S. (*See* "Electrical Papers," Vol. II., pp. 119 to 168, for detailed theory of the distortionless circuit.)

In § 213 we saw that even in the electrostatic theory leakage would allow us to signal as fast as we liked provided we could do it with an infinitesimal current. This was not because the circuit was made distortionless, but on account of the infinitely rapid charge and discharge. Now the inclusion of the influence of self-induction shows that we can do the same with a finite leakage conductance, and have finite distortionless signals, due to waves of the purely elastic type. Given R and S then, if L should be so small that the introduction of K of the proper amount to reach the distortionless condition should produce unreasonable attenuation, then one way of curing this would be to increase L. For then a smaller amount of leakage will serve. The bigger L, the smaller need K be, and when it is very big, then very little K is needed. This brings us round to the case at the end of § 215, where we had elastic waves with little attenuation on an Atlantic cable got without any leakage, and since we see now that very little leakage is needed to bring about the distortionless condition, we conclude that it is approximately distortionless without the leakage.

(To be continued.)

ON THE PIEZO-ELECTRIC PROPERTY OF QUARTZ.*

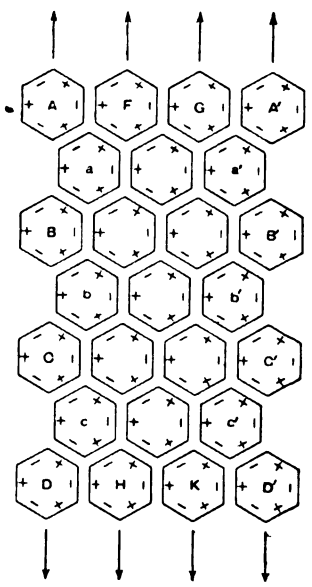
BY LORD KELVIN.

The sides of the hexagonal constituent molecules (as we shall see presently in considering the electric effects of changes in their relative positions) must make angles of 30deg. and 90deg. with the sides of the hexagon of the natural crystal. The annexed diagram shows, in section perpendicular to what is commonly called "the axis of the crystal," a rectangular group of 25 molecules, with its length perpendicular to a pair of parallel sides of this hexagon; and with, for its thickness, rows of alternately four molecules and three molecules. The molecules marked A *a* B *b* C *c* D, A′ *a* B′ *b*′ C′ *c*′ D′ are in the two sides of the thin plate of the Curies' experiment; and the breadth of the plate is made up in my model by building up layer over layer each similar to the one shown in the diagram, all similarly oriented, of course. The zinc and copper faces of the molecules are marked + and − respectively. The air-spaces between them are exactly equal in the diagram, which is intended to represent the undisturbed configuration.

Suppose, first, the molecules to have each of them equal quantities of positive and negative electricity on its whole surface: which would be the case if they were given in this condition, and brought together from infinite distances to the positions shown in the diagram, each kept perfectly insulated. Let them be all now metallically connected (by infinitely fine wire, understood). The total quantity of electricity on each will remain zero, because every interior molecule experiences equal positive and negative induction from neighbours; and, except for an infinitesimal irregularity due to the four corners, A, D, A′, D′, which we neglect, each individual molecule in the end rows A F G A′, and D H K D′ experiences equal positive and negative inductions from neighbours; and each pair of molecules, *a*B, *b*C, *a*′B′, *b*′C′, in the side rows experiences equal sums of positive and of negative inductions from neighbours. Thus, for example, the effect on B *b*, of the connecting, is merely to cause a quantity of positive electricity to flow from *b* to B, because two faces of B gain positive and one gains negative, while two faces of *b* gain positive and three gain negative.

Let, now, all molecules in the side rows A *a* B *b* C *c* D be kept in metallic connection with one another, and so also all in the other side, A′ *a*′ B′ *b*′ C′ *c*′ D′; but let all the other connections be annulled, and the molecules left insulated. This corresponds to the Curies' silvering of the two sides of their plate.

Under these conditions, let such forces be applied to the boundary molecules as shall produce the simple elongation of the whole configuration indicated by the arrows. This will leave the air-spaces between faces parallel to the lines of elongation unchanged, and will increase all the others, each by



the same difference. The electrical result will be the release of approximately equal quantities of electricity, whether positive or negative, from all of the opposed faces not parallel to the lines of elongation. Each interior molecule will lose, very approximately equal quantities of positive electricity from two of its faces, and of negative from two others. Each of the molecules in the end rows, F G. . . , H K. . . , will lose positive electricity from one face and negative from one other face.

But each projecting molecule, such as B, on one side will lose positive electricity from two inward faces, while each non-projecting molecule, *b*, loses positive electricity from two inner faces and negative from other two. Thus, of the eight inner faces of B and *b*, there is neither gain nor loss from two, there are equal losses and gains from four, and there are losses of positive electricity from two. The positive electricity thus freed from the inward faces of the projecting molecules A B C D in the side A *a* B *b* C *c* D settles itself on the bare faces to the left; similarly, negative electricity, freed from the inward faces of the other side, A′ *a*′ B′. . . becomes deposited on the bare faces to the right, which is the Curies' result.

The quantities of electricity thus developed are calculated in a moment, if we suppose the thicknesses of the air-spaces to be small in comparison with the diameters of the molecules. So also is the electrostatic inductive capacity of the assemblage; and thence the difference of electric potential between the two silvered sides, if none of the developed electricity is drawn off

* Addendum to a Pape read in Section A of the British Association.

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A POTENTIOMETER METHOD OF MEASURING THE ELECTROMOTIVE FORCE OF TRANSFORMERS.

BY BERNARD P. SCATTERGOOD, B.A. OXON.

(*Concluded from page 645.*)

Of course, it is not necessary in practice to make use of the graphic method at all; the balancing point is easily found by a simple calculation. If d_1 d_2 are two nearly equal deflections on opposite sides of it, and V_1 V_2 the standard voltages at which these deflections respectively occur, the balancing point V_0 is, by the principle of similar triangles, given at once by the formula

$$V_0 = V_1 + \frac{d_1}{d_1 + d_2}(V_2 - V_1).$$

Or from the two nearly equal deflections the E.M.F. required may be found, perhaps more easily, and with sufficient accuracy, by the following rule, the *rationale* of which will be easily understood:—Add to the sum of the two standard voltages

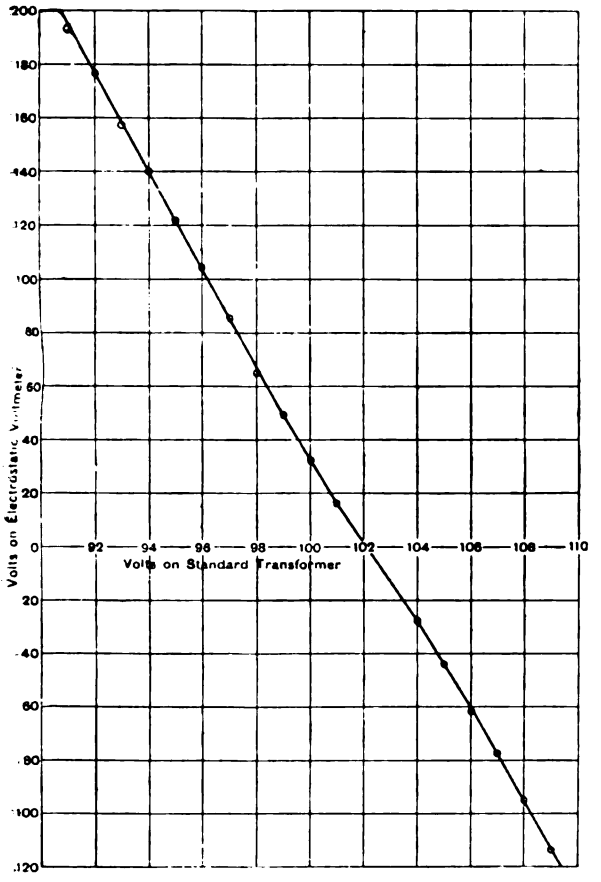

FIG. 3.

the difference of the two deflections divided by the (actual) conversion ratio of the auxiliary transformer used; half the sum will be the E.M.F. required. Or, using the preceding notation

$$V_0 = \tfrac{1}{2}(V_1 + V_2 + n(d_1 - d_2)),$$

n being the conversion ratio.

An example may make this clearer. Taking at random two readings from Table I. we see that one auxiliary transformer gives, with 95 volts on the standard, a deflection of 135, and with 109 volts a deflection of 130. The E.M.F. of the transformer which is being tested is therefore

$$\tfrac{1}{2}\left(95 + 109 + \frac{135 - 130}{20}\right),$$

or 102·13 volts, which is sufficiently near to the true voltage namely 102·15.

When a batch of transformers of the same type is to be tested, it will be found quicker, and quite sufficiently accurate, to take two readings, as just indicated, of the first one tested, and from them to determine the slope of the line, *i.e.*, the "virtual conversion ratio" of the auxiliary. When this value has been found it can be applied, in the case of the remainder, to calculate from a single deflection, the E.M.F. acting in the circuit; and hence, the standard voltage being known, the E.M.F. required is at once found. For instance, the virtual conversion ratio being found to be 1 to 19, if a standard voltage of 93 gives a deflection of 127, the secondary E.M.F. will be

$$93 + \frac{127}{19}, \text{ or } 99{\cdot}68 \text{ volts.}$$

It may be pointed out that an error in the calibration of the voltmeter used will make practically no difference in the accuracy of the results obtained, as the only effect will be to alter the slope of the line joining the two observed points; the line will still cut the horizontal axis at the balancing point. An instance of this has just occured in my own experiments. Owing to an accident the multicellular voltmeter which was being used indicated between 30 and 40 per cent. low; but the voltage of a transformer which it was used to measure, agreed, to within the fiftieth of a volt, with the result obtained when the voltmeter was reading correctly.

As to the degree of accuracy obtainable, this is limited (assuming the standard voltage to be exactly known) solely by the conversion ratio of the auxiliary transformer used. With a steady primary voltage the voltmeter can easily be read, supposing the deflection to be at the best part of the scale (a condition which can always be attained), to a quarter of a volt; this, with a step-up transformer of ratio as low as 1 to 20, means a possible error of only one-eightieth of a volt in the estimation of the E.M.F. acting in the circuit; that is to say, if the E.M.F. of the standard is known exactly, that of a transformer giving about 100 volts can be measured with an accuracy of one part in eight thousand. This is, of course, a precision which is quite unnecessary in practice; but the great advantage of the method is the possibility which it holds out of obtaining rapid and sufficiently accurate measurements under conditions which, as before pointed out, would ordinarily make such measurements impossible.

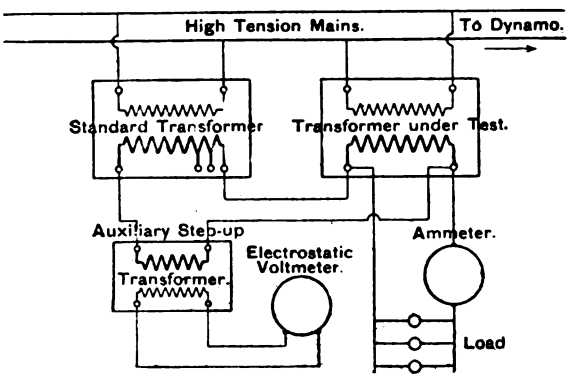

FIG. 4.

For instance, suppose, as an extreme case, the primary voltage to vary during the test between the normal and 10 per cent. higher than normal. The voltmeter readings will of course be unsteady, and it may be impossible to get a reading to be relied upon as being accurate within five volts; yet even this only means an error of one quarter of a volt in the E.M.F. of the transformer which is being measured. If an attempt were made to measure the secondary voltage directly the error would, of course, be five volts. Or, again, suppose the primary voltage to be steady, but, through an error in the calibration of the high-tension voltmeter, to be actually 10 per cent. higher than it is believed to be, say, 2,200 instead of 2,000. The secondary voltages of both standard and transformer under test are now each of them 10 per cent. high, and this is also the case with their difference, and, therefore, with the voltmeter deflection. But if another nearly equal deflection be taken on the other side of the balancing point, this will also be 10 per cent. high; hence the balancing point itself, as determined in the manner shown in Fig. 3 will remain

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unaltered, being the same as when the primary voltage is normal.

It will be seen from the above instances how extremely elastic this method of testing is; with primary voltage unsteady, or wrongly estimated, or both, and with an incorrect voltmeter, it is still possible to get measurements which are quite sufficiently accurate for all practical purposes.

An obvious modification is to use, instead of the step-up transformer and voltmeter, an electro-dynamometer of fairly high resistance. I have obtained good results with a Siemens instrument which has a constant of 0·02 and a resistance of about 12½ ohms. This method is not so sensitive as the one just described, and has the disadvantage that the readings are affected to a much greater extent by the frequency of the alternations, and therefore by variations of dynamo speed; but it is simpler, and will often be found more convenient, especially where great accuracy is not desired.

After the "potentiometer" method had been successfully applied to the measurement of open circuit E.M.F., it became of interest to see whether that of a loaded transformer could not be determined in the same way. The results were quite satisfactory, and developed a method of testing by which not only secondary E.M.F., but lag of primary current behind primary E.M.F. and therefore the power factor of a transformer at different loads, can readily be measured.

The connections in this test are shown in Fig. 4, and are, as will be seen, altogether similar to those in the last case, except that a load of lamps, or a non-inductive resistance, is placed across the secondary terminals of the transformer to be tested, with an ammeter in circuit to measure the current.

The following table gives readings taken with the transformer previously tested, working on a non-inductive wire resistance.

Table II.—*Showing observed Voltmeter Deflections at Different Standard Voltages, with one, two, three and four Auxiliary Transformers, at a Load of 15·4 amperes (No. 1,669).*

Voltage of standard.	Voltmeter deflections.			
	Auxiliary, one transformer.	Auxiliary, two transformers. (Fig. 4, B.)	Auxiliary, three transformers.	Auxiliary, four transformers. (Fig. 4, A).
90	196·5	189·0	182·0	179·0
91	177·5	171·0	165·0	161·5
92	159·5	154·0	148·5	144·0
93	141·5	136·25	131·0	127·5
94	125·0	119·5	114·25	111·5
95	109·5	104·5	99·5	95·75
96	95·25	90·5	85·75	82·0
97	83·25	79·0	75·0	71·75
98	74·5	70·5	66·5	63·25
99	69·5	65·75	62·0	58·5
100	70·25	66·3	62·5	60·25
101	75·75	72·25	68·75	66·0
102	85·75	82·0	78·5	75·5
103	97·75	94·0	90·75	87·0
104	112·5	108·25	104·0	101·0
105	128·0	123·0	118·0	116·0
106	146·5	140·0	134·0	129·5
107	163·0	156·0	150·0	146·0
108	179·5	173·0	166·0	162·0
109	198·0	190·0	182·0	179·0
110	218·5	211·0	203·0	196·0

The current was kept throughout as nearly as possible constant at 15·4 amperes. The same transformers were used for the upward conversion as in the previous case, and, as before, were used in four combinations, one singly, and two, three, and four in parallel.

It will be seen at once that in this case the effective E.M.F. in the circuit, as measured by the voltmeter deflection, never becomes zero. It falls to a minimum, higher or lower according to the auxiliary transformer used, and then rises again. Two sets of readings have, as before, been plotted on squared paper (Fig. 5, A and B), and along with them has been plotted a third, C, which is the curve corresponding to an auxiliary transformer of infinite impedance, and which is actually a hyperbola. The way in which the points of this curve have been derived will be explained shortly. On the same diagram has been plotted part of the curve corresponding to a load of about seven amperes, and also, for the sake of comparison, the (corrected) no-load curve of the same transformer. It will be noticed that the axes of the new curves are shifted to the left with respect to that of the no-load curves; that is, the minimun deflection occurs at a lower standard voltage than the minimum (zero) reading in the case of the unloaded transformer.

Now it is clear that at some point between 90 and 110 volts on the standard, the E.M.F. of the transformer which is being measured must be equal to that of the standard. Why, then,

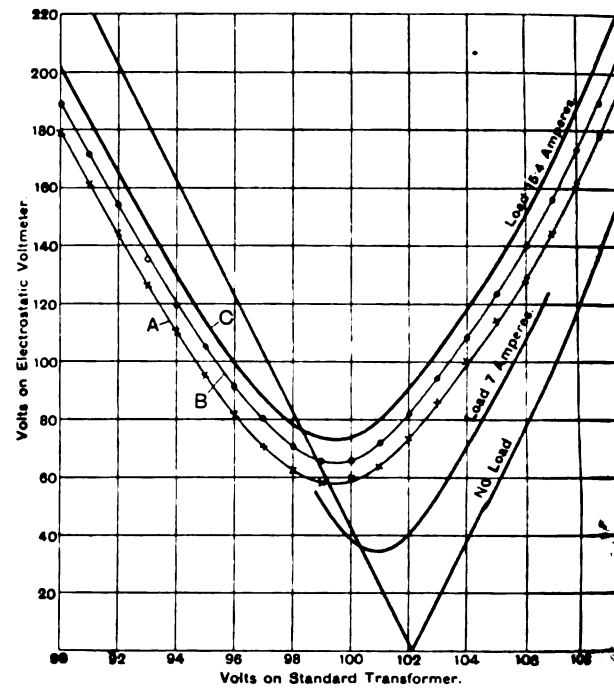

Fig. 5.—E.M.F. Curves of a 2-H.P. Lowrie-Hall Transformer (No. 1,669). A, Auxiliary Four 2-H.P. Transformers in Parallel; B, Auxiliary Two 2-H.P. Transformers in Parallel; C, Theoretical Curve.

do we not get a balance—that is, zero deflection—at this point? The answer is to be found in the phase difference of the two opposing electromotive forces. In fact, we know that as the load on the secondary of a transformer is increased the phase of the secondary E.M.F. is slightly accelerated with respect to that of the impressed primary E.M.F. (*vide* "Fleming," Vol. II., p. 454); and that instead of being exactly opposed to the latter, as in the case of an unloaded transformer, its position will be slightly in advance of this, to an extent which depends upon the load. Representing this state of things by a diagram (Fig. 6), if we

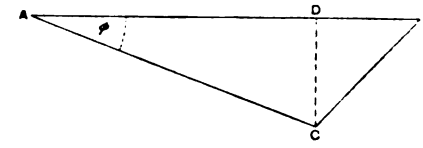

Fig. 6.

call the E.M.F. of the standard A B, that of the transformer under test will be represented in direction and magnitude by such a line as C A, inclined to A B at an angle ϕ. (In the unloaded transformer C A and A B are coincident, or $\phi = 0$.) The third side, B C, of the triangle represents the resultant E.M.F. which is impressed at the terminals of the auxiliary, and the deflection on the voltmeter is therefore proportional to this line

Now the secondary E.M.F. of the transformer under test and its phase are, for a given load, both of them constant quantities; that is to say, in the figure C A and ϕ are both fixed. The length of the line A B, however (representing the standard voltage) is variable; and it is easy to see that as the point B travels in the figure from right to left (that is, as the standard voltage decreases), the line B C grows shorter, reaching a minimum when B has arrived at a point, D, such that

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B C is perpendicular to A B; and then increasing again according to the same law as that of its decrease. In other words, the effective E.M.F. in the circuit, as measured by the voltmeter deflection, falls until it is in quadrature with the standard voltage, and then rises again. Further, we see from the figure that when the minimum is reached, since A C has now become the hypotenuse of a right-angled triangle, A D C, the E.M.F. of the transformer under test is equal to the square root of the sum of the squares of the resultant E.M.F. (known from the voltmeter deflection) and of the standard voltage at the point where the minimum occurs.

Putting B C = y, B D = x, and D C = a, we have at once

$$y^2 - x^2 = a^2,$$

which is seen to be the equation of a hyperbola of eccentricity $\sqrt{2}$.

In the curves of Fig. 5 I have plotted on the vertical scale, not the effective electromotive forces B C, but voltmeter deflections (*i.e.*, B C divided by the ratio of conversion, $\frac{1}{20}$); and these distances again are all reduced in the ratio of 10 to 1. The effect of these two alterations is to change the eccentricity of the hyperbola from $\sqrt{2}$ to $\frac{\sqrt{5}}{2}$; for the equation of the curve now becomes

$$\frac{10^2}{20^2}\,y^2 = x^2 + \frac{a^2}{20^2};$$

or,

$$\frac{y^2}{4} = x^2 + \frac{a^2}{400};$$

or,

$$\frac{y^2}{\frac{a^2}{100}} - \frac{x^2}{\frac{a^2}{400}} = 1;$$

therefore, if e be the eccentricity,

$$e^2 - 1 = \frac{100}{400}, \text{ or } e = \frac{\sqrt{5}}{2}.$$

The hyperbola marked C in Fig. 4 was calculated in the following way:—The standard voltage at which the minimum observed readings occur was determined by careful measurements on the curves A and B, and was found to be 99·35 volts; the vertical through this point was taken as the axis of the hyperbola. From the four observed minima the minimum of the corrected curve (the quantity here called a) was found by direct proportion; and finally, the deflections y, corresponding to different values of the standard voltage x, were calculated from the equation,

$$y^2 = 4x^2 + \frac{a^2}{100},$$

and plotted about a vertical axis passing through the point of minimum deflection.* As regards the permissibility of determining the corrected minimum by extrapolation in direct proportion from the observed minima, it may be said that experiment shows that this would not be allowable in the case of transformers having a large magnetic leakage, as the minimum thus calculated would be too low; but so far as the determination of the secondary E.M.F. of the transformer is concerned, a considerable error in the estimation of this minimum makes but little difference in the result.

As an example of the order of the error which might be made, we may calculate from the curve C in Fig. 4 the E.M.F. of our transformer at a load of 15·4 amperes. The corrected minimum deflection is 73, therefore the minimum resultant E.M.F. in the circuit is $\frac{73}{20}$, or 3·65 volts, occurring at a standard voltage of 99·35; hence the required E.M.F. is $\sqrt{(99{\cdot}35)^2 + (3{\cdot}65)^2} = 99{\cdot}42$ volts, which agrees closely with the result obtained by a direct measurement in the ordinary way.

If the minimum were taken at 60 (the actual minimum with one auxiliary transformer) instead of 73, the E.M.F. would work out to 99·39 volts. Finally, to take an extreme case, let the minimum be taken as zero; the E.M.F. would then be simply that of the standard, or 99·35 volts; differing by only 7 parts in 10,000 from that calculated from the corrected curve. It would therefore in most cases be found sufficiently accurate to take, as the E.M.F. required, the voltage of the standard at the point where the minimum occurs.

It is not necessary to plot the whole curve in order to find the point of minimum deflection. Three observations are sufficient to determine the point with sufficient approximation to accuracy. One deflection is observed on one side of the minimum, and as far away from it as the adjustment of the standard voltage will allow, and two others on the other side of the minimum, such that the deflection previously obtained lies between them in numerical value. The two latter deflections should be taken with a difference of only one volt on the secondary of the standard. Then if d_1 d_2 d_3 are the three deflections (d_3 being greater than d_2) and V_1 V_2 V_3 the corresponding standard voltages, it can easily be verified that approximately

$$V_0 = \tfrac{1}{2}\left(V_1 + V_2 + \frac{d_1 - d_2}{d_3 - d_2}\,(V_3 - V_2)\right).$$

Furthermore we can calculate the angle ϕ by which the secondary E.M.F. has been advanced from its original position with respect to the primary E.M.F. For in the triangle of electromotive forces we have

$$\tan\phi = \frac{\text{minimum resultant E.M.F.}}{\text{standard voltage at which minimum occurs}};$$

or in the case taken,

$$\tan\phi = \frac{3{\cdot}65}{99{\cdot}35} = 0{\cdot}0367, \text{ or } \phi = 2^\circ\,6',$$

and the supplement of this angle, 177° 54′, is the phase difference between the primary and secondary E.M.F.

But we know that at full load, and indeed at loads considerably less than this, the secondary E.M.F. is in exactly opposite phase to the primary current. Hence the angle between the primary E.M.F. and the primary current is 2° 6′, and the cosine of this angle is the power factor at this particular load. Now the cosine of 2° 6′ is 0·994, or practically unity, which is in agreement with the result of recent experiment.

The application of this "potentiometer" method of testing transformers to the investigation of the phase-relations of primary and secondary electromotive forces seemed to me to present features both of interest and utility sufficient to warrant me in presenting a brief description of it to the readers of this paper. It appears also to be capable of considerable further development, of which, and of other practical applications which have suggested themselves to me, I hope to say more on a future occasion.

* It may be pointed out that the asymptotes of this hyperbola are inclined to the horizontal axis at an angle tan $^{-1}\frac{1}{n}$, where n is the conversion ratio of the auxiliary transformer used. They are, in fact, simply the "no-load curve" shifted to the left.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, October 27th.

PHYSICAL SOCIETY.

5 p.m. (1) Mr. C. E. Rimington: "On Air-Core Transformers." (2) Two experiments. Mr. W. B. Croft, M.A.: "On the Rings and Brushes in Crystals, and Electrical Radiation in Copper Filings."

WEDNESDAY, October 25th.

INSTITUTION OF MECHANICAL ENGINEERS
(At the Institution of Civil Engineers).

7:30 p.m. Mr. Benjamin A. Dobson, of Bolton: "On the Artificial Lighting of Workshops."

The Electric Light at the Royal Exchange.—The Royal Exchange is at last to be lighted by electricity, and merchants who go on 'Change will now no longer be compelled—as has happened on several occasions—to suspend business on foggy days owing to insufficiency of light. Correspondence on the subject has recently taken place between Mr. S. Montagu, M.P., and Mr. J. Watney, the clerk of the Gresham Committee (who manage the property within which the Exchange lies). The result is that the Committee have now decided to have the quadrangle lighted electrically as soon as possible, and a letter to this effect has been addressed by the Clerk of the Committee to Mr. Montagu. The Committee hope to complete the work before Christmas.

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(The Oldest Electrical Journal.)

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.

Editorial, Publishing, and Printing Offices :

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON.

Telephone No. 2714. *Telegrams :* "ELECTRICIAN NEWSPAPER, LONDON."

All Letters relating to Subscriptions, Advertisements, and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed "Coutts and Co."*

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SPECIAL NOTICE.

With the issue of "THE ELECTRICIAN" of the 10th November, 1893, will be published (Gratis to Subscribers) a fine STEEL-PLATE PORTRAIT of

Mr. JOSEPH WILSON SWAN.

AMBIGUITY IN SCIENCE.

Ambiguity in science means false science. Properly speaking, we should say ambiguity mixed with science; for, ambiguous science, or ambiguity in the nature of science, involves a contradiction in terms. Still, as pure gold may be admixed with earthy matter, so may pure science be muddled up with a great deal that is non-science and often nonsense. The essence of all exact knowledge, or science, is (we have it on the authority of SOCRATES) definition; and the essence of a perfect definition is that it shall be explicit, free from ambiguity, that its terms shall verbally cover the entire extent of the ideas which it is to convey, but that they shall not pass the bounds of that extent by one jot or tittle. Such is the ideal definition; it is a thing about which there cannot be the least rational quibble or ground of dispute. Unfortunately this high ideal is far from being attained in many of our departments of science. It is the natural consequence of the progress of the human race, intellectually, from a state of complete ignorance through widening stages of incomplete knowledge, that there have arisen on the field of human knowledge isolated patches of wisdom, separated by dark tracts of ignorance, insulated oases on an arid desert. These several separate regions of knowledge have been long in revealing any trace of their true connection to the whole, or of their relation to one another; so that the processes of thought, and the definition of thought, in each has proceeded almost, if not quite, independently for many generations. It would be scarcely possible for such to be the case without the introduction of a great deal of ambiguity and confusion whenever two or more of these isolated patches of knowledge become blended into one united area. Confusion arises on many grounds; we may pause to notice two in particular. The one is the adoption of precisely

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the same term for two or even more totally different areas of thought; the other is the converse, the use of several different phrases to cover identically the same area of thought. Instances of the latter are abundant, but of less importance than the former. Electrical engineers do not, for example, label the currents in a conductor with names indicative only of their sources, unless, indeed, there is an inherent difference between the currents themselves; while recognised medical authorities talk glibly of their "cathodic currents," and "anodic currents" their faradisation, and auto-conduction. The use of the same term to convey several distinct ideas is more common, and often of more serious consequences. A simple illustration occurs in the case of the over-loaded word "solid." The geometrician thinks of three axes of space, the physicist calls up the contrast of "fluid," the engineer contrasts a "hollow," other people have other ideas; all conjured up by the one word "solid." Another example is the unhappy word "polarisation"; while, in connection with the use of physico-mathematical symbols, nothing could be more remarkable than the use of the symbol μ in optics and in electromagnetism, and the result arising from the union of those two sciences.

But the unavoidable ambiguities which arise when two previously isolated systems or branches of science are blended are tolerable as compared with the wanton employment of standard and universally recognised terms to cover the nakedness of parts on the border of a quite unrelated science, as has been perpetrated recently by a leader of biological science. Whatever may be the views adopted as to the relationship of life to physical force, there can be no dispute that physiology and its allied sciences, of histology and morphology, are in close touch with physical and chemical sciences; and that nothing can be gained, but rather that a great deal will be lost, by importing such explicit phrases as energy from the latter into the former sciences, for the purpose of veiling the ignorance of the latter with a hall-marked name. In his Presidential Address before the British Association, Dr. Burdon-Sanderson unblushingly fixed the word *specific* before the word *energy*, without any intention whatever of specifying either quantity or quality of energy in either quality or quantity of matter, but for the sole purpose of applying this hybrid, meaningless phrase, "specific energy," to the vital functions of protoplasmic cells. "The term energy," writes Dr. Lodge in *Nature*, "is a physical one given us by Thomas Young, and it has been fought for by us through a great part of this century. It will be wanted seriously by physiologists before long, in its proper sense, and it will be a thousand pities if they misuse it." We would even go further, and aver that the term energy is wanted seriously by physiologists even now, in its proper sense, and is used by them. For in terms of what other quantity than physical energy can they estimate the katabolism or the anabolism of a living cell? Certainly not in terms of the amount of matter, for that measurement would often be the very inverse; nor, indeed, in terms of the chemical constituents of the protoplasmic cell (even if it could be estimated), for the relationship is uncertain and by no means stable. No; physiologists and all students of nature require the term energy in its established usage; and it is sheer vandalism to ruthlessly force it to signify something else, especially something which is beyond the border of inanimate physical agency. Physico-chemical, or even mechanical, "explanations" of life may be indulged in, if they assist in formulating ideas; but let the new ideas be labelled with new names to suit them, and not with those torn from their fastenings to other sciences.

Physicists should jealously guard the term energy, as Dr. Lodge thus does. It is daily used in a loose sense by engineers, and electrical engineers especially are liable to talk of the transmission of energy when they mean the transmission of power. Engines, dynamos, cables, and motors are all designed with reference to power; secondary batteries and coal bunkers alone are considered with reference to energy. A definition is a serious affair, and ideal definitions are perhaps rare. The definition of energy as "the capacity for doing work" ought to suffice for most people, but metaphysicians are inclined to complain that "energy" has been ear-marked by modern writers, and that the ἐνέργεια of Aristotle is the same now as it was two thousand years ago. A young Oxford philosopher, against whose attacks we were recently defending the accurate use of the word energy, and who was somewhat interested in learning that by an expenditure of work energy could be stored, argued that, according to our definition, the sharpness of a knife is a form of potential energy, stored up by work done on a grindstone, and giving the knife a greater capacity for doing work! To such shocking results are we led by Ambiguity in Science.

THE INCANDESCENT LAMP AND ITS MANUFACTURE.*

BY GILBERT S. RAM.

(Concluded from page 643.)

Relation between Light and Power.

It has already been stated that the light given out by an incandescent filament increases, after a certain temperature has been attained, at a much greater rate than the power spent in the filament. The relation of the light to the power, or to the pressure or the current, has been the subject of much study and speculation. Many and various formulæ have been given

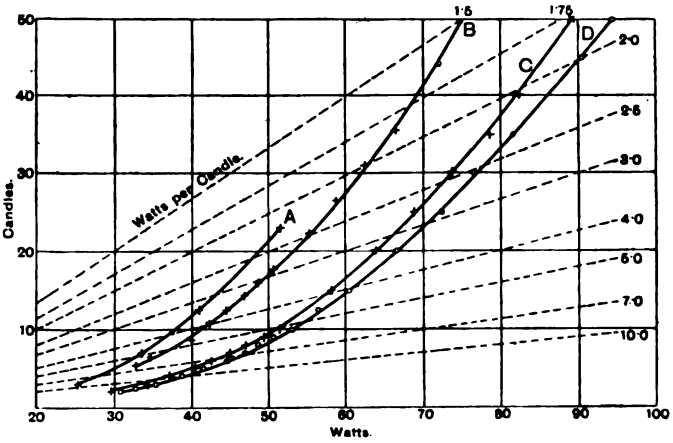

Fig. 41.

by different investigators. Some of them are nearly correct when applied to certain lamps, but are found to be quite useless when applied to others. No formula yet given appears to satisfy all cases. The reason probably lies in the imperfections of the lamps. The filaments of different lamps vary in their behaviour at different temperatures, and the vacuums also vary.

In 1882 Prof. A. Jamieson showed that the candle-power of incandescent lamps was approximately proportional to the sixth power of the pressure, and, therefore, to the sixth power of the current, since the resistance of the filament when incandescent does not alter much.

The most recently published tests have been carried out under the direction of Prof. Ayrton, at the Central Institution of the City and Guilds of London, and are published in part

* Abstract from a book to be published early next month by *The Electrician* Printing and Publishing Company (Limited). All rights of republication reserved.

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in *The Electrician* of July 15, 1892. These tests are valuable, as they appear to have been carried out with great care to eliminate various errors, and the observations were made by three observers.

It is shown by these tests that there is a definite relation between the logarithms of the candle-power and of the volts, amperes, or watts respectively of each lamp.

As, however, the tests referred to are not carried above the temperature of about 4 watts per candle-power, the author introduces here some tests which he has made up to a much higher temperature.

Lamp B.						Lamp D.					
C.P.	Volts.	Amps	Watts	Ohms	a V^n	C.P.	Volts.	Amps	Watts.	Ohms	a V^n
5·3	29·0	1·13	32·6	25·7	5·15	2·0	30·0	1·03	30·9	29·1	2·33
6·2	30·0	1·15	34·5	26·1	6·2	3·0	32·0	1·1	35·2	29·1	3·22
8·8	32·5	1·23	40·0	26·4	9·52	4·0	33·0	1·15	37·9	28·7	3·92
10·6	33·0	1·23	42·2	2·:·8	10·3	5·0	34·5	1·2	41·4	28·8	5·05
12·5	34·0	1·31	44·5	26·0	12·07	6·0	36·0	1·24	44·7	29·0	6·34
14·2	35·0	1·34	4·:·9	26·1	14·18	7·0	37·0	1·27	47·0	29·2	7·4
16·0	36·0	1·36	48·9	26·5	16·4	8·0	37·5	1·3	48·7	28·9	7·97
17·7	36·5	1·39	50·7	26·3	17·65	9·0	38·0	1·33	50·5	28·6	8·5
22·2	38·0	1·45	55·1	26·2	22·0	10·0	39·0	1·36	53·0	28·7	10·0
26·5	39·5	1·49	58·8	26·5	26·8	12·5	40·2	1·4	56·3	28·7	11·68
35·4	42·0	1·58	66·4	26·6	37·4	15·0	41·8	1·45	60·5	28·6	14·5
44·0	43·5	1·66	72·1	26·2	45·0	20·0	43·7	1·51	66·0	29·0	18·4
53·0	45·0	1·7	76·5	26·4	51·4	25·0	45·5	1·58	72·0	28·8	24·0
62·0	46·0	1·75	80·5	26·4	61·3	30·0	47·0	1·62	76·3	29·0	27·6
71·0	46·8	1·78	83·5	26·4	66·8	35·0	48·5	1·68	81·5	28·9	32·6
80·0	47·8	1·81	86·5	26·4	74·6	45·0	51·2	1·77	90·5	28·9	44·2
106·0	50·5	1·9	96·0	26·6	100·0	50·0	52·2	1·85	94·5	28·2	48·9
124·0	52·0	1·94	101·0	26·8	117·8	60·0	54·2	1·88	102·0	27·8	60·7
142·0	53·0	1·98	105·0	26·8	130·0	70·0	55·4	1·92	106·2	28·8	68·0
159·0	55·0	2·05	112·8	26·8	159·0	80·0	57·0	1·98	113·0	28·8	80·0
177·0	56·0	2·07	116·0	27·0	174·5	90·0	57·8	2·01	116·3	28·8	86·5
195·0	58·0	2·13	123·6	27·2	210·0	100·0	59·6	2·08	124·0	28·8	102·0
212·0	60·0	2·2	132·0	27·3	252·0	120·0	62·0	2·17	134·5	28·6	127·0
230·0	61·8	2·22	137·2	27·8	296·0	140·0	64·8	2·25	145·0	28·8	166·0
248·0	65·0	2·3	149·5	28·3	389·0	160·0	68·0	2·35	160·0	28·4	211·0
...	...	...	...	...	...	180·0	69·0	2·38	164·0	28·9	230·0
...	...	...	...	...	...	200·0	72·5	2·49	181·0	29·1	300·0
...	...	...	...	...	...	250·0	80·0	2·7	216·0	29·6	518·0
...	...	...	...	...	...	295·0	90·0	2·8	252·0	32·2	1000·0

The lamps B, C, D, are of Edison-Swan manufacture, and lamp A is an unflashed amyloid filament lamp, the test of which was, however, not carried very far.

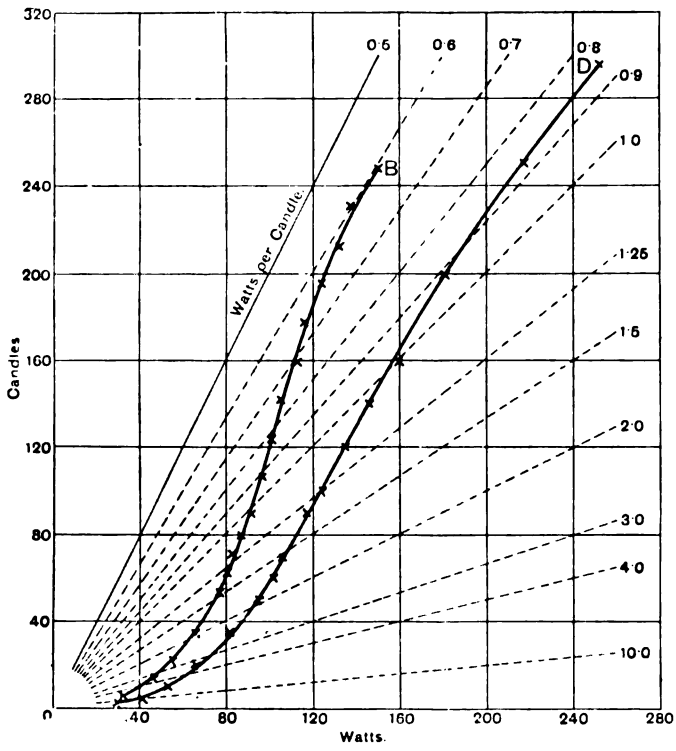

Fig. 42.

Fig. 41 shows the curves of watts and candle-power up to about 2 watts per candle-power, and Fig. 42 shows the results of lamps B and D run up to their breaking points. The dotted lines show the watts per candle-power.

It will be noticed that both the curves (Fig. 42) turn over at the higher readings. This is caused by the disintegration of the filament and its consequent change in emissivity and resistance, and by the blackening of the bulb. The direction of the curves above the point where rapid disintegration begins depends, among other things, upon the length of time during which the lamp is kept at each temperature while the observations are being made. The curve of a lamp which is kept at 1 watt per candle power for some time may, for instance, be made to bend over so much that it will never reach 0·9 watt per candle-power, as the lamp will break before arriving there. It will be noticed that lamp B attains a much higher efficiency than lamp D. The observations at the higher readings in each case were, however, made as quickly as possible.

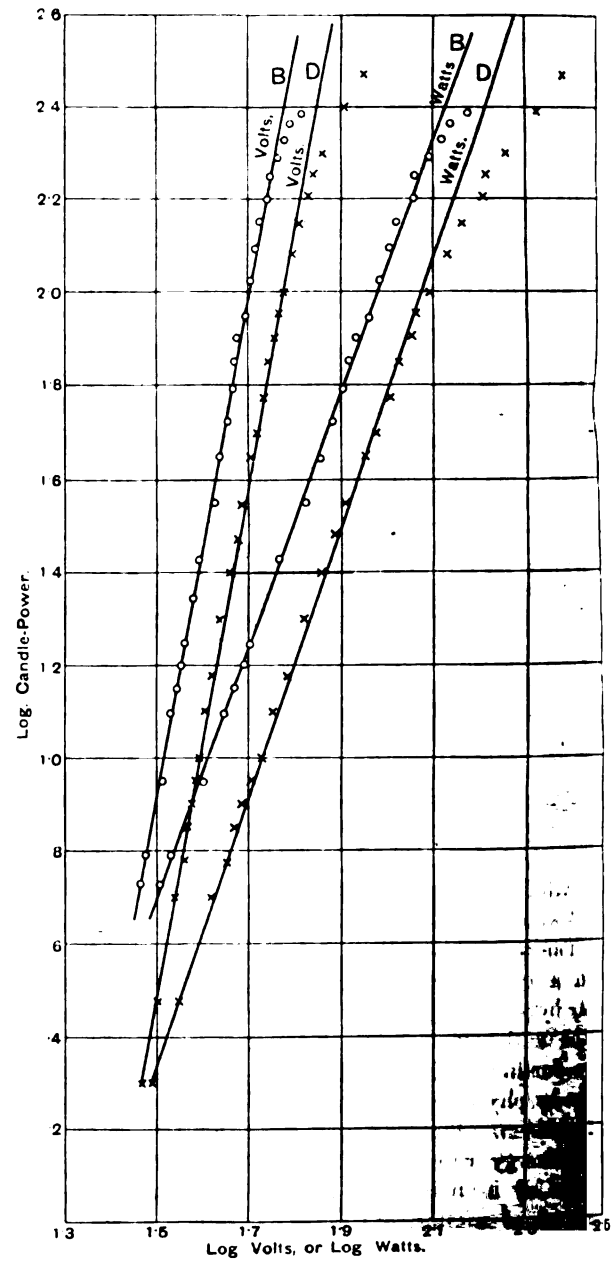

Fig. 43

Fig. 43 shows the relation between the logarithms of the candle-power and of the volts and watts respectively. Up to the point where the lamp begins to rapidly deteriorate it will be noticed that the observations in this figure lie nearly in straight lines. Sufficiently so to suggest that they ought to be exactly in straight lines. Assuming that they should do so, the expression $C.P. = a\,V^n$. Where C.P. = candle-power and V = volts, a and n, being constants, would enable us to find the candle-power at any voltage when the value of a and n is known.

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In order to find the value of a and n for any lamp two observations at least must be made.

If c.p. = candle-power at the lower reading,
" v = volts " " "
" C.P. = candle-power " higher "
" V = volts " " "

then
$$n = \frac{\log \frac{\text{C.P.}}{\text{c.p.}}}{\log \frac{\text{V}}{v}},$$

and
$$a = \frac{\text{c.p.}}{v^n} = \frac{\text{C.P.}}{\text{V}^n}.$$

The observations, from which the value of a and n are obtained, must be made with the greatest care, and should

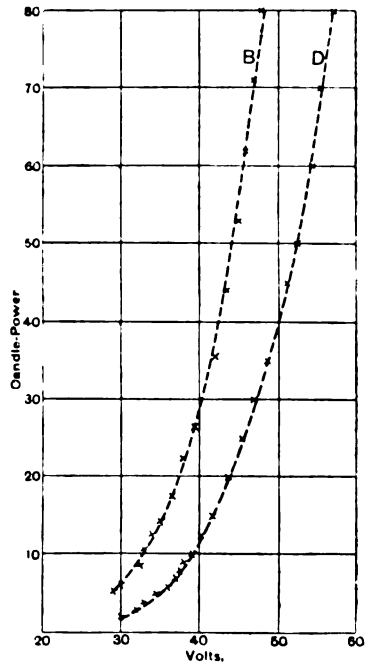

Fig. 44.

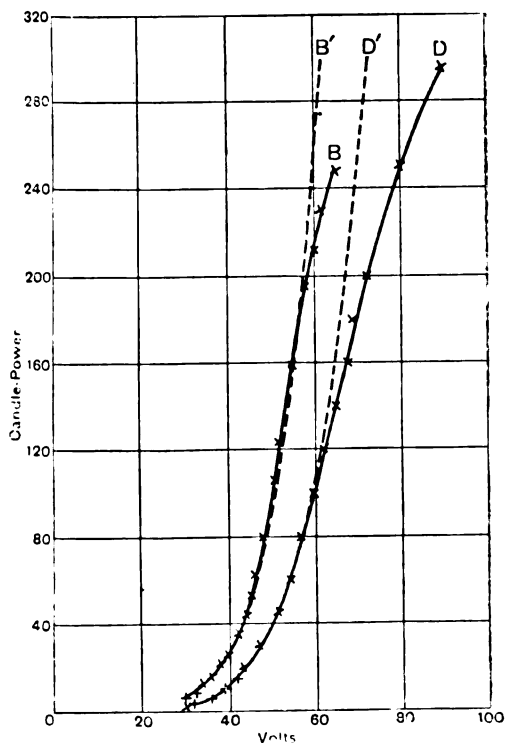

Fig. 45.

be as wide apart as possible. A very slight error in the test will give a wrong value to the exponent n, and will make the calculated results quite wrong.

In the case of lamp B, taking the readings of 30 volts 6·2 c.p., and 55 volts 158 c.p., the value of n is found to be 5·35, and $a = 7·76 \times 10^{-8}$.

In the same way for lamp D, at 39 volts 10 c.p., and 57 volts 80 c.p. $n = 5·51$ and $a = 1·695 \times 10^{-8}$.

In Figs. 44 and 45 the dotted curves show the values calculated on the above basis. The crosses mark the observed values. Over the lower portion of the curves the observed and the calculated values lie very close together. In Fig. 45 it will be seen that the curve B representing the actual observations definitely takes a different direction from B', representing the calculated values at about 180 c.p., or at an efficiency of 0·65 watt per candle. The curve D separates from D' at 100 candles, corresponding to an efficiency of 1·25 watts per candle-power only. This would seem to show that lamp D was an inferior one to lamp B.

That great care is necessary in making the tests, for a and n can be seen in the case of lamp B. If two observations only were made, and these were, say, those at 30 volts 6·2 c.p. and 35 volts 14·2 c.p., the value of n would come out at 5·38, which is very nearly right, these two observations lying almost exactly on the straight line in Fig. 43. If, however, the tests were those of 32·5 volts 8·8 c.p., and 34 volts 12·5 c.p., the one reading of candle-power being a little low and the other a little high, the value of n would be 7·9, and the calculated results would be quite wrong. These two observations lying one a little above and the other a little below the line in Fig. 66, where they are indicated by the dotted circles, while the observations from which the correct values are obtained are shown by the full circles.

It is probable that the relation of candle-power to watts is a more constant one among different lamps than that of candle-power to volts or amperes. In the latter case the degree of constancy of the resistance of the filament throughout the range of the test has an effect upon the form of the curve, whereas in the former case it has no such effect.

LAMP-HOLDERS.

(*Continued from page 639.*)

Having briefly reviewed in our last issue the four patents under which lamp-holders are now made in this country by licensed manufacturers, we proceed to describe some lamp-holders, ancient and modern, with special reference to the patents. The earliest practical lamp-holder in England was the cardboard contrivance of Swan. Many such holders are in existence to-day, as curiosities, but few lamps adapted for them remain unbroken. Fig. 1 is an illustration * of the lamp, sheath, and holder. The sheath on the stem of the lamp is made of black glazed cardboard with a wooden ring at the base. Thin brass springs are attached to this base by screws, which serve to connect the platinum wires from the lamp to these spring contact plates. The holder consists merely of a wooden ring with a pair of sheet brass guides into which the sheath slides; the springs lock themselves into these guides. The arrangement in several respects resembles Edison's holder, illustrated on page 639.

If any obstacles to the use of capped lamps are raised by the Edison-Swan United Company, it is possible that holders for loop lamps may again be in request. The holders themselves are still protected, it is true, assuming the validity of Swan 5,702, December 28, 1881; but they can be made for a few pence by licencees, and the royalty is but trifling. The spiral spring used by Swan for giving the "outward push" was inconvenient, and many different patterns have been used in later holders. It is still to be found in the price list of the Edison and Swan Company, and is shown in Fig. 2 full size. The use of crossed loops of spring wire was one of the first improvements. These are shown in Fig. 3, which represents one of the seven kinds made by the Edison and Swan Company. Fig. 4 shows a lamp-holder made by the General Electric Company of boxwood or ebony with crossed-wire loops.

* From Mr. G. S. Ram's forthcoming book on the "Incandescent Lamp and its Manufacture."

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Fig. 5 is a holder made by Woodhouse and Rawson. The "outward push" springs are, perhaps, the best that have been offered; they depend for their effect upon the shape of the lamp

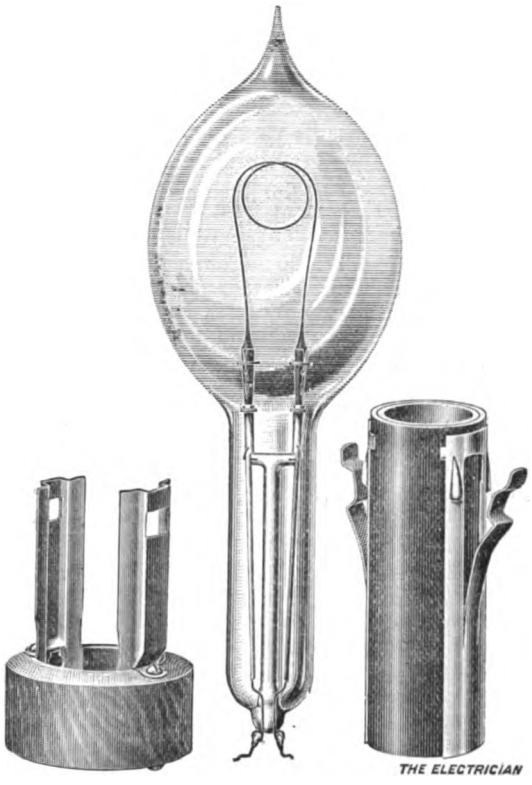

Fig. 1.—Swan's Cardboard Lamp-holder.

bulb. While there are probably thousands of users of electric light who have never seen a loop lamp, "bottom loops" are recommended for use on stiff fittings where there is much vibration. A lamp-holder has been specially designed for use in the Navy, where the firing of big guns might smash every lamp

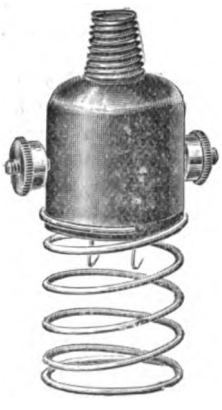

Fig. 2.—"Ediswan" Lamp-holder with Spiral.

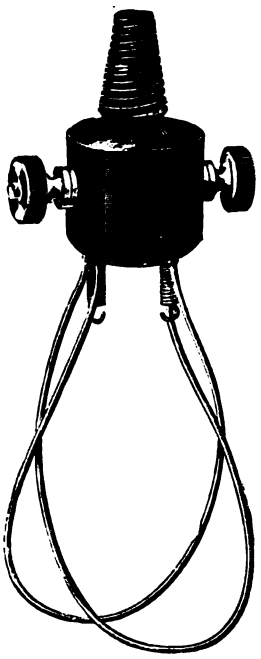

Fig. 3.—"Ediswan" Holder with Crossed Wire Loops.

in a ship if precautions were not taken. Fig. 6 shows the standard Admiralty pattern of lamp-holder. A modification of the Woodhouse and Rawson outward push springs is adopted; there are three springs instead of four, and they form part of a collar which can be set in position by set screws. Very stiff spiral springs can thus be employed. The holder consists of three parts. The one shown on the left of the figure is a shell of brass provided with a nipple screwed for $\frac{3}{8}$in. Into this shell an ebonite plug is fitted. The wires are passed through a hole in the centre, and are fastened under flat-headed screws in the front of the plug. These screws screw into brass pins, which pass through to the back of the plug, and are soldered to spiral springs, which pass through again to the front. The springs are made of No. 20 German silver wire. The ebonite plug enclosed in the brass shell fits into the slotted collar, set screws passing through the slots into the ebonite. Looped lamps have been used in many cases in order to avoid the hopeless ugliness of the ordinary socket-holder for capped lamps. Special attention has been paid to this matter by Messrs. Faraday and Sons, whose very

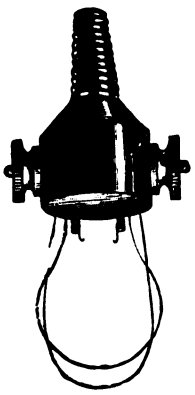

Fig. 4.—General Electric Company's Wooden Holder for Loop Lamps.

Fig. 5.—Woodhouse and Rawson Wooden Holder for Loop Lamps.

graceful fittings would be ruined by a clumsy holder, while such an appendage would hardly be noticed on a massive and gaudy polished brass "electrolier." Fig. 7 is an illustration of a holder, which was at one time made by Messrs. Faraday and Sons, but we understand that the manufacture is discontinued for the present, owing to the existence of some of the patents to which we have referred. In this holder, as in several others, the "outward push" is rigid, while firm contact is secured by spiral springs.

Holders for large lamps of 50 c.p. and upwards are made with side springs, but "lug terminals" are provided on the lamps instead of loops, and the springs exert no outward push, but on the contrary take the weight of the lamp.

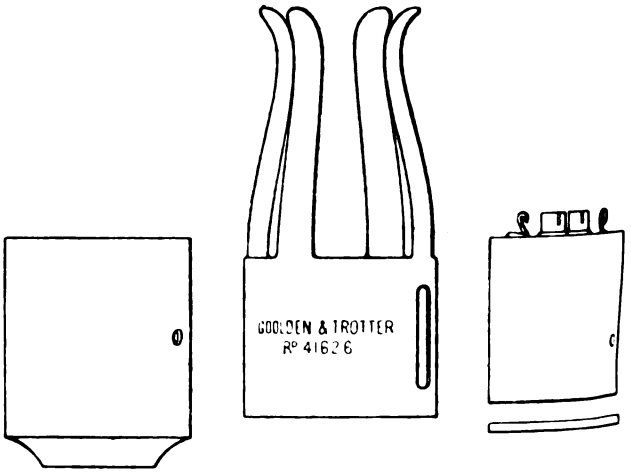

Fig. 6.—Admiralty Pattern Lamp-holder, showing separate parts.

We cannot afford space to discuss the many ingenious inventions of Mr. Alfred Swan, who has designed a large number of lamp-holders, and has constructed most of them in the peculiar form of glass which he has called vitrite. Patents No. 2,528, 1883, and 5,158, 1883, are adapted for vitrite lamp-holders for end loops or side loop lamps, but patent No. 6,319,

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1884, shows a vitrite cap with contact pieces on the flat end, together with spring contacts and bayonet catch. The date of this patent is April 12th, about six weeks after Dornfeld. Many thousand lamp-holders were made in exact accordance with this patent; the weak point of them was brittleness and the difference of expansion by heat of the vitrite and of the metal. No. 9,158, 1884, of June 19th, shows several modifications, one of the most practical being the disuse of the small vitrite projections which engage with the bayonet slot in the brass tube, and the use of grooves in the vitrite material in which

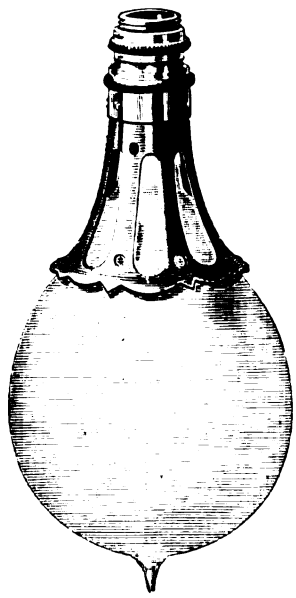

FIG. 7.—Messrs. Faraday and Sons' Holder.

depressions formed on the brass tube engaged. An elaborated form of holder is described in No. 15,025, 1884, the spring-contact pieces being made of hexagon tube with good buffer contacts. Octagon brass tube was used for the nipple which was firmly embedded in the vitrite (Figs. 8 and 9). Besides these patents, Mr. Swan had several for shade carriers and other modifications.

Before proceeding to describe the modern lamp-holders, we may refer briefly to the other patents to which allusion has been already made. The patent of J. W. and C. Swan relates to a

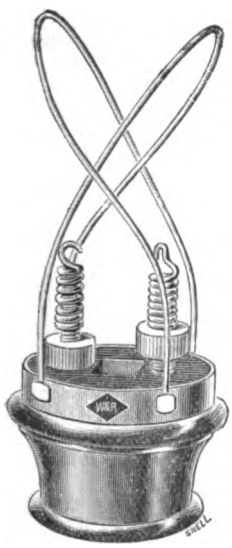

FIG. 8.—Vitrite Holder for Loop Lamps.

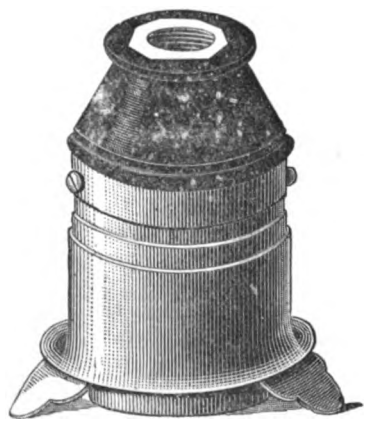

FIG. 9.—Vitrite Holder for Capped Lamps.

wooden lamp-holder with terminal loops, consisting of two or more closely-wound coils of wire ending in a hook. It was intended that the loops on the lamp should be nipped in one of the coils, which were to be formed of spring wire, with the object of making a good contact, and avoiding any spiral springs giving a longitudinal pull for the purpose of making a firmer contact. It is noteworthy that all these lamp-holders of Swan were arranged with a taper screw thread, adapted to replace an ordinary gas burner.

One other early patent remains to be mentioned, viz., that of Henri Pieper, No. 4,854, 1885. This holder consists of an open spiral of stout wire into which the Edison socket may be screwed. It is provided with a very simple switch. This lamp-holder is in common use on the Continent, but is not often seen in this country.

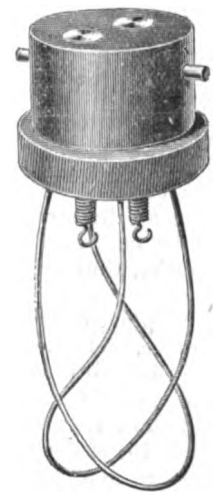

FIG. 10.—"Ediswan" Adapter for Bottom Loop Lamps and Ordinary Lamp-holder.

FIG. 11.—"Ediswan" Adapter for Bottom Loop Lamps and Edison Socket.

Having briefly reviewed the older forms of lamp-holder, we may allude to a device which was employed to bridge over the two systems of end loops and caps. When socket-holders began to come into general use, and while looped lamps were

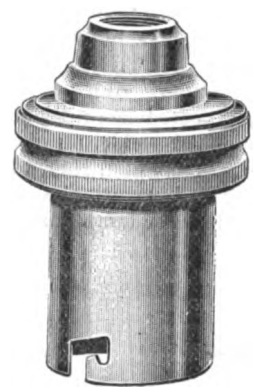

FIG. 12.—"Ediswan" No. 14 Lamp-holder.

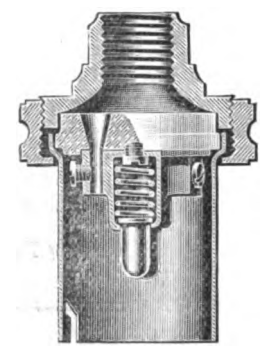

FIG. 13.—"Ediswan" No. 14 Lamp-holder (section).

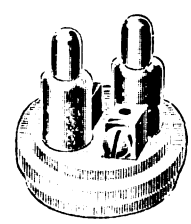

FIG. 14.—Base of "Ediswan" No. 14 Holder (front view).

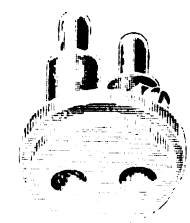

FIG. 15.—Base of "Ediswan" No. 14 Holder (back view).

still common, an adapter for fitting looped lamps to socket-holders was very convenient. Such adapters are shown in Figs. 10 and 11. Whether such adapters may be said to form part of a lamp-holder or no we cannot venture to decide, but if the Edison-Swan Company propose to keep their lamp-holder patents in force with strictness it seems possible that the device may

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be, at all events for foreign manufacturers, a matter of some importance. Seeing that so many firms have taken licences for the manufacture of lamp-holders, litigation under these patents is extremely unlikely. We, therefore, have less hesitation in commenting upon the possible result upon glow lamps made by other makers, whether at home or abroad. Since the Edison patent covers all metal contacts which are attached to the base of a lamp, it is difficult to see how lamps can be provided with caps suitable for use with socket holders. If the licence to make lamp-holders includes the right to make caps and to fit them on to the lamps, there will be no difficulty, and we hope, but are not confident, that this will be the case. The Edison and Swan United Company have as yet given no indication whatever of their course of action with regard to these patents, nor is there any reason why they should do so.

We may now turn to some well-known lamp-holders at present used in this country. They may be divided into two classes, although the distinction is not always recognised, viz., for front wiring and for back wiring. Where a lamp-holder is to be screwed to a bracket, or other fitting, it is obvious that no connections can be made at the back of the base without some special arrangement for getting at the terminals. But where a pendant is used, a cap can be unscrewed from the back of the holder and pushed up the wire, thus exposing the terminals at the back.

There seems to be but little room for improvement in the standard lamp-holder of the "Ediswan" make, and known as the No. 14 holder of the Edison and Swan United Company. It is a holder of the front-wiring class, and is clearly shown in Figs. 12 to 15; the construction is so well known that description is unnecessary. The base (Figs. 14 and 15) of holders of this kind has been made by different makers in a variety of different materials. Now that the manufacture of white porcelain has been carried to such a perfection, allowing very accurately moulded pieces to be produced, this material leaves little to be desired. Steatite, slate, and even vulcanised fibre have been used. This latter material, which no doubt offers a fair insulation so long as it is kept dry by the warmth of the lamp, is now only used, so far as lamp-holders are concerned, for key sockets or switch-holders, and other more or less complicated devices. The blocks into which the conductors pass from the back through the taper holes, and to which they are secured by set screws, are made in one piece, in the "Ediswan" pattern, with the barrel of the spring plunger. With a small amount of care, as may be reasonably expected from gas-fitters and ironmongers' men, there is no danger of accidental contact between loose strands with this holder. The union ring, which holds the barrel to the back collar, and keeps the whole together, seems in this as well as in all other lamp-holders of this pattern, to be rather heavy.

(To be continued.)

PRIMARY BATTERIES IN THEORY AND PRACTICE.*

BY W. R. COOPER, M.A.

PART I.

(Continued from page 638.)

Polarisation.

Polarisation is a more serious defect than local action, as far as the utility of a cell is concerned. The latter is simply a waste of energy, but does not diminish that which is useful except as a whole; the former results in no waste, but diminishes the energy which is available at any moment.

Polarisation may occur whenever the chemical change is a reversible one, or when the action is such that the conditions are equally favourable to its reversal. Such is the case in the simple voltaic element, consisting of Zn, Cu, and dilute H_2SO_4. The Zn is dissolved and hydrogen is liberated at the copper plate, or

$$Zn + H_2SO_4 = ZnSO_4 + H_2.$$

But the reaction may also take place in the opposite direction, for the hydrogen is a free agent, and we may have the reverse change:—

$$H_2 + ZnSO_4 = H_2SO_4 + Zn,$$

the zinc sulphate being reduced, and zinc being deposited on the copper plate.

The change in the negative plate also results in a transition resistance, and the introduction of a different contact force between the plate and the electrolyte. The former is generally neglected, but the latter is of importance. If a plate that has been polarised by a film of hydrogen is removed, it is found to be electrically different to an unpolarised plate of the same kind, being positive to it. This affords a further proof of contact force. The same phenomena may be produced by gas that is not deposited electrolytically. If a plate of Pt is placed in an atmosphere of hydrogen it absorbs the gas, and is found to possess the same properties as a polarised plate. The polarisation is partially removed by washing the plate with water or KOH, and is wholly destroyed by boiling in HNO_3, or by ignition.

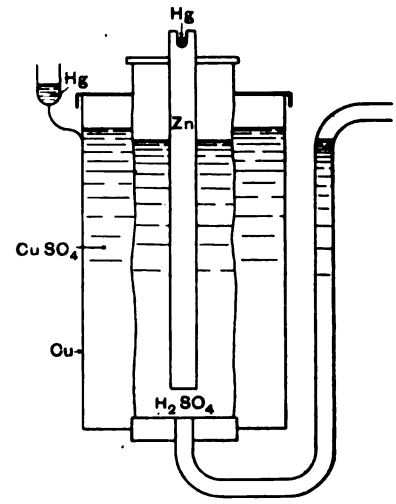

FIG. 5.—Daniell's Cell.

In 1836 Daniell gave an account of experiments that he conducted with a cell consisting of Zn, Pt, and H_2SO_4. He found that the current fell off very rapidly, but recovered at once upon boiling the platinum plate in HNO_3 or HCl. The longer the cell was in use the more readily did the polarisation occur. This is no doubt due to the increased quantity of $ZnSO_4$ present, Zn being then more readily deposited by the hydrogen. If allowed to stand the cell recovers; for the hydrogen displaces more Zn or combines with free oxygen, and the Zn deposited on the platinum plate is dissolved by local action.

Upon allowing the cell to run for 30 hours, Daniell found the current to fall off completely, and a very considerable deposit of zinc upon the platinum. To remedy this defect he conceived the idea of adding a substance which the hydrogen should precipitate in preference to the Zn, and selected $CuSO_4$ as the most suitable. This cannot be simply added to the H_2SO_4; for, although the Zn be amalgamated, sufficient local action occurs to liberate hydrogen, which would immediately act upon the $CuSO_4$ and deposit Cu on the Zn rod.

Daniell, therefore, constructed a cell consisting of a copper cylinder, within which was a membranous tube of ox gullet. The outer vessel contained the solution of $CuSO_4$; the inner one contained the Zn rod and dilute H_2SO_4. From the lower part of the inner tube there passed a glass syphon, as shown in the figure, by means of which the resulting $ZnSO_4$ might be drawn off as fresh acid was added. In this manner a very constant current could be maintained for any length of time, provided the $CuSO_4$ were maintained saturated.

The ox gullet was soon replaced by the ordinary porous pot, and it was found unnecessary to withdraw the $ZnSO_4$ that is

* Paper read at a Students' Meeting of the Institution of Electrical Engineers, May 19th.

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formed. A solution of this salt is now very generally employed instead of H_2SO_4, and it is only necessary to maintain it sufficiently dilute to ensure the ready removal of the salt from the zinc rod on formation.

The very great difference between the power of a Daniell cell, and that of a cell without a depolariser, is strikingly shown by the curves of discharge as given by Prof. Carhart (*see* Fig. 6). The former, however, is not quite free from polarisation, and it is found that it depends upon the current density employed.

There are two defects in the Daniell cell. The porous pot increases the resistance, and the $CuSO_4$ in time passes by osmotic pressure to the Zn upon which the Cu is deposited. On this account it is inefficient and unsuitable for prolonged action.

Any substance, liquid or solid, which is capable of combining with hydrogen may be used as a depolariser. Thus, any substance containing an oxidising agent such as peroxides, the halogens, HNO_3, chromic acid, bichromates, sulphur, &c., are suitable for the purpose. For example, the Grove contains HNO_3; the Leclanché, MnO_2; the Edison-Lalande, CuO; and so forth. The great advantage of a solid depolariser is that the porous pot may generally be dispensed with.

These theories of polarisation are at the best unsatisfactory. The resistance introduced along with polarisation appears to have been neglected, and it is not easy to distinguish between

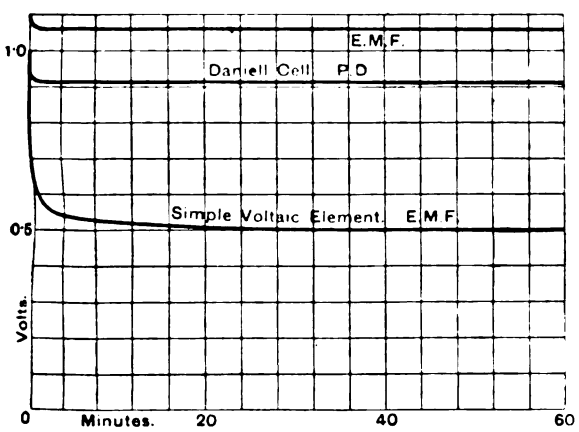


FIG. 6.—Polarisation Curves.

the two. There is no reason why polarisation should not be due simply to back action, if we consider the actions occurring in a chain (rigid, as it were), so that corresponding actions occur simultaneously at either end. Upon the formation of a molecule of $ZnSO_4$, the hydrogen at the other plate may be regarded as simultaneously reacting upon it, being unaffected by the intervening molecules.

Hydrogen is not the only polariser. In the Daniell cell, employing $ZnSO_4$, zinc is the polariser. In the cell already referred to (*see* Fig. 1), consisting of copper, NaCl, and $CuCl_2$, only the copper and the NaCl are the essential elements. Sodium is the polariser, and the $CuCl_2$ is simply the depolariser.

Thermo-Chemical Relations.

A clearer idea of what takes place in a cell is obtained by considering the thermal changes in the way indicated by Lord Kelvin in 1851, when he brought forward his dynamical theory of electrolysis. Let e be the electro-chemical equivalent of one of the ions of the electrolyte supplying energy to the circuit, and θ the heat produced by the combination of unit weight of this ion with the second of which the electrolyte is composed; then, if J is Joule's equivalent, the total quantity of work per second performed by the chemical change is $J\theta e . Q$, Q being the quantity of electricity passing. But the work is also equal to E Q where E is the E.M.F. of the cell. Hence:

$$E Q = J \theta e Q;$$

or, $$E = J \theta e \quad \text{in C.G.S. units,}$$

showing that the E.M.F. can be determined from a knowledge of the chemical changes involved, and that it is directly proportional to the heat of combination of the electro-chemical equivalent of the ion, or of that quantity of the ion which is deposited in unit time by unit current.

This formula may be put in a somewhat more convenient form. Since Joule's equivalent is 41·6 millions, we may write

$$E = 4{\cdot}16\, \theta e \text{ volts,}$$

the ampere now being the unit of current. Also the electro-chemical equivalents and the chemical equivalents are proportional. Hence, if the electro-chemical equivalent of hydrogen is known, that of any other element is obtained by multiplying this by its chemical equivalent. The electro-chemical equivalent of hydrogen is 0·00001036. Hence

$$\theta e = 4{\cdot}16 \times 0{\cdot}00001036\, \theta' = 0{\cdot}000043\, \theta'$$

where θ' = heat of combination of one chemical equivalent of the ion. If E = 1, we see that 23,200 heat units correspond to one volt, or 46,400, if the atomic weights of bivalent elements are the chemical equivalents employed, or double the atomic weights of the univalent elements.

A large number of determinations of the heats of combination have been made by Thomsen; and, since the electro-chemical equivalents of the ions are well known, it is not difficult to calculate the E.M.F. of any particular cell. For example, if we deal with gramme molecular weights, the heat of formation of $ZnSO_4$ from Zn and dilute H_2SO_4 amounts to 37,730 gramme centigrade heat units; or, in other words, this amount of heat is evolved by the combination of 65 grammes of Zn with 98 grammes of H_2SO_4 to form $ZnSO_4$. Now the equivalent of one volt is 46,400 heat units. Hence the calculated E.M.F. of the simple Zn – Cu couple in dilute H_2SO_4 amounts to

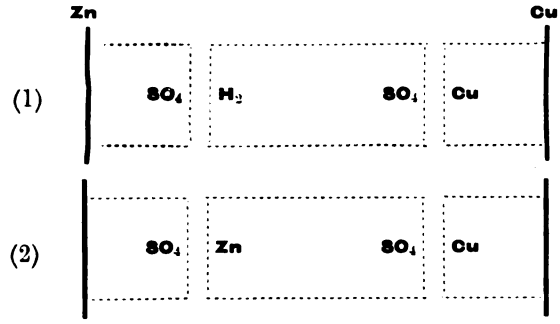
$$\frac{37{,}730}{46{,}400} = 0{\cdot}8 \text{ volt.}$$

If a depolariser is employed, as in the Daniell cell, energy is thereby added to the circuit, for there are now two chemical changes involved instead of one. $ZnSO_4$ is still formed; but the liberated hydrogen breaks up the $CuSO_4$, and thus there is a further evolution of heat, amounting to 12,400 units. The total evolution of heat is therefore 37,730 + 12,400 = 50,130, giving an E.M.F. of

$$\frac{50{,}130}{46{,}400} = 1{\cdot}08 \text{ volts,}$$

which is in agreement with experiment.

The result is the same if the sulphuric acid is replaced by a solution of $ZnSO_4$. In the one case H_2SO_4 is broken up, and is reformed, and in the second case $ZnSO_4$ undergoes the same change:—



In both cases these changes neutralise each other, and the energy of the system is unaffected. This, coupled with the fact that the energy is transferred, enables such an electrolyte to be used.

There is, however, one point of which no account is taken in this investigation. It is tacitly assumed that amalgamated zinc is in every way equivalent to zinc in the ordinary condition, but there appears to be very little evidence strictly in favour of this assumption. If the total energy is unaffected, it is reasonable to suppose that the zinc forms a distinct substance with the mercury, and that the heat evolved as the inner particles come into amalgamation is abstracted from the system as the atoms pass from the amalgam to form $ZnSO_4$.

It is often found that the calculated E.M.F. is at variance with that which is observed. For example, the calculated

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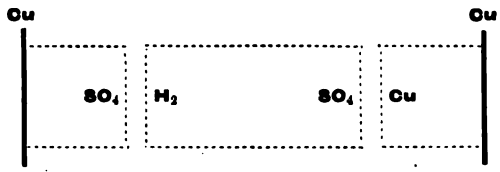
E.M.F. of the De la Rue cell is 1·18 volts, whereas the observed value is 1·05 volts; in the case of the Grove the calculated value is 2·08 volts, whereas observation gives 1·95 volts. The discrepancy may be assigned to two or three causes. It is improbable that the theory is false; it is obtained by equating the same quantity of energy in two different forms, and there can be no error in so doing. If the thermo-chemical data are correct we can only conclude that we are dealing with a different quantity of energy to that which we had supposed. In other words, chemical changes in the cell have been omitted or misunderstood, and when we come to a point like that it is hard to say what we do understand. For example, we may be dealing with an hydrated salt or acid instead of the substance that we suppose. In the case of the Grove, the acid may be of a different strength to that with which the heat of combination was determined, or we may be dealing unconsciously with bodies which are present and entirely disregarded.

Examples of such cases are easily found. If a strip of copper is placed in a test tube containing dilute H_2SO_4 in the lower part and $CuSO_4$ in the upper, electrolytic action sets in: copper is dissolved by the H_2SO_4 and deposited by the $CuSO_4$. We have apparently the change which is expressed below :—

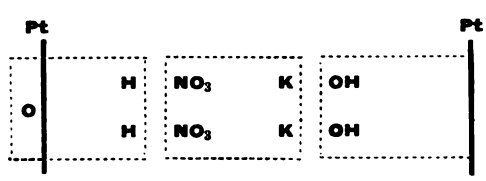


Now $CuSO_4$ has a negative heat of combination of about 12,000: *i.e.*, copper will not dissolve in H_2SO_4 without the aid of heat. And even supposing it had a positive heat of combination, we are here concerned with two electromotive forces in the same circuit which are equal and opposite; viz., that due to the formation of $CuSO_4$, and that due to its decomposition. The cell then cannot work under the assumed conditions. But if we suppose oxygen to be present in the H_2SO_4, as it certainly is, then we are dealing with different conditions, and it is possible for the cell to work.

As another example we may take Becquerel's cell, already alluded to (*see* Fig. 2), which consists of a porous pot containing HNO_3 standing in an outer vessel filled with KOH solution. Two platinum plates are employed, and it is supposed that the current is generated by the interaction of the two electrolytes. But it is impossible to obtain a current by the neutralisation of an acid with an alkali. We have, of course,

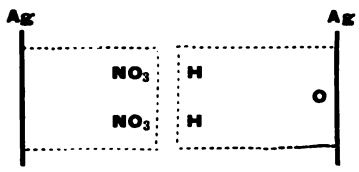
$$KOH + HNO_3 = KNO_3 + H_2O,$$

but nothing is liberated, whereas the liberation of an ion is essential to the working of a cell. It is, as it were, a closed circuit, and there is no transfer of energy. Yet the cell gives a current. This is probably due to the presence of atmospheric oxygen and upon this supposition the change may be represented thus :—



The hydrogen of the nitric acid would then combine with the oxygen in solution at the Pt plate to form water; KNO_3 would result, and hydroxyl would break up at the other Pt plate into water and oxygen. Faraday observed in his "Experimental Researches" that such a cell could not work unless one of the plates were replaced by zinc; but such a change reduces it to one of the ordinary form, either the HNO_3 or the KOH being then superfluous.

Reference has already been made to the solution of metals by electrolytic action and the double action of solvents. A good example of the latter is afforded by the solution of silver in HNO_3. It is well known that this metal will not dissolve simply in HNO_3; but it does so if a little nitrous acid is present, which apparently supplies the necessary depolariser. Assuming this to be the case, the reaction may be represented as follows :—



the oxygen being probably derived from a nitrous compound, the remaining part of which is not indicated.

Similarly, amalgamated zinc dissolves in dilute H_2SO_4 upon the addition of HNO_3. A voltaic cell is formed. Part of the zinc is acted upon by the H_2SO_4; another part forms, as it were, the external circuit and the other metallic element with the depolariser which is HNO_3.

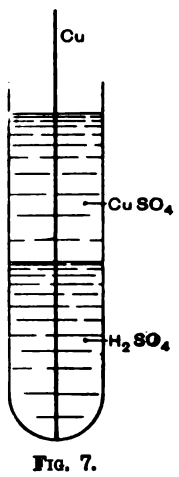


FIG. 7.

It will be noticed that Kelvin's "Dynamical Theory" takes no account of the negative plate, for no chemical action occurs there. It therefore follows that no variation in the E.M.F. should be caused by changing the negative element. For example, the E.M.F. of the Grove should be the same as that of the Bunsen, but it is generally found to be somewhat greater. The carbon of the Bunsen may possibly have some effect on the acid, and it is probable that they would give the same result if compared under truly comparable conditions.

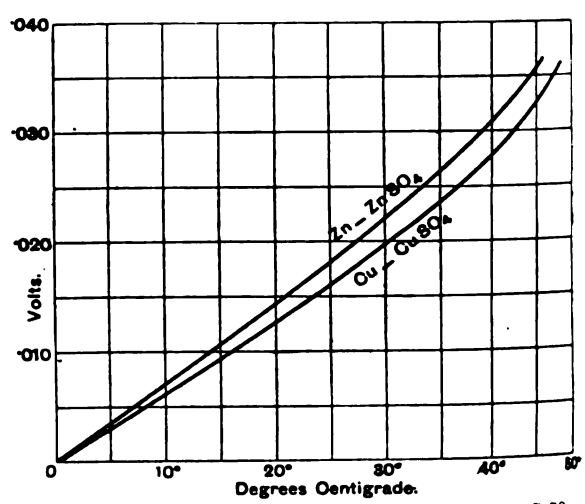


FIG. 8.—Thermo-Electric Power of $Zn - ZnSO_4$ and $Cu - CuSO_4$.

From these considerations it also follows, if the contact theory be true, that the differences caused in the contact forces with the electrolyte and the positive element, by the introduction of a different negative plate, should balance, so that the sum of the forces of contact throughout the cell should remain unchanged. This seems somewhat improbable.

Temperature Coefficients.

Since the heat of combination of a compound varies with the temperature at which it is determined, it is theoretically

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possible to determine by this means the temperature coefficient of any given cell. Unfortunately thermo-chemical data have not been studied as yet with sufficient care to enable this to be done. But from what we do know, it appears that the coefficient may be positive or negative.

There is another way of looking at temperature coefficients which is of interest. We may suppose that the variation in

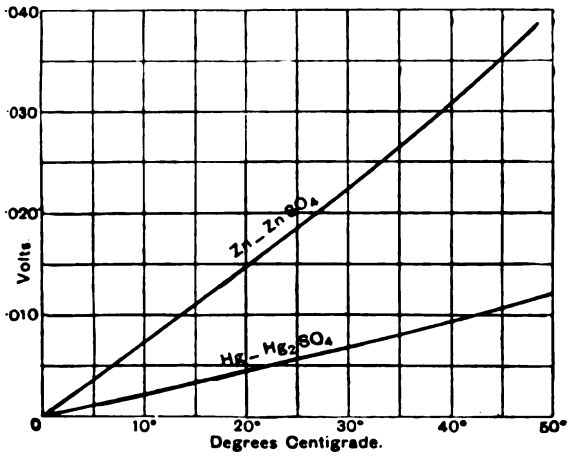

Fig. 9.—Thermo-Electric Power of $Zn - ZnSO_4$ and $Hg - Hg_2SO_4$.

E.M.F. *is due* to thermo-electric couples. There may be a certain E.M.F. set up between one of the plates and the electrolyte, and a similar one at the other plate, if the temperature at that part is also varied. This theory is taken up by Prof. Carhart ("Primary Batteries," by Prof. H. S. Carhart), who, however, neglects the possible E.M.F. caused by the junction of the electrolytes, which, by experiment, appears to be extremely small.

The thermo-electric power, or the potential difference per degree rise of temperature, was determined for both $Zn - ZnSO_4$ and $Cu - CuSO_4$, as shown by the curves that are reproduced (*see* Fig. 8). It is seen that the thermo-electric power of $Zn - ZnSO_4$ is slightly greater than that of $Cu - CuSO_4$. Since these couples oppose each other, it follows that the resulting change in E.M.F. should be very small: the calculated value is only 0·00006 volt per degree, the E.M.F. falling by this amount for rise of temperature. The actual temperature coefficient Prof. Carhart found to be 0·000067, which agrees very fairly with the above.

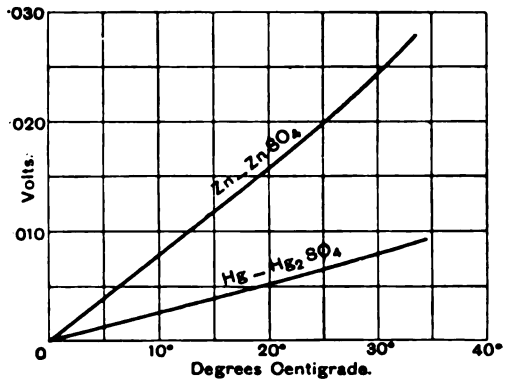

Fig. 10.—Thermo-Electric Power from Clark Cell.

The temperature coefficient of the Clark cell, calculated in the same manner, amounts to 0·000381, which is very much lower than the generally accepted value, but agrees very closely with the value 0·000386, which Prof. Carhart found for the cells in his possession. The curves which are reproduced show the results obtained. One of them (Fig. 9) simply gives the thermo-electric powers observed. The other (Fig. 10) gives the differences of E.M.F. observed by separately heating the junctions in an experimental Clark cell.

(To be continued.)

COMPENSATING GENERATORS AT DERBY.

The theory of the special form of armature winding, and of field-magnet design, by which Mr. W. B. Sayers arrives at his self-exciting dynamo, has been fully discussed in recent numbers of *The Electrician*. On pages 60 and 66 of the issue of May 19, 1893, we gave an account of Mr. Sayers' Paper before the Institution of Electrical Engineers. On September 22nd and 29th we referred to his British Association Paper, and to the actual dynamos which are now running at the Derby railway station electric light works. We are now able to give a set of scale drawings (Fig. 1), showing the elevation, transverse section and plan of one of these machines, which, as it will be remembered, are the joint invention of Messrs. W. B. and J. Sayers.

Two of these machines, which have been manufactured by Messrs. Mavor and Coulson, of Glasgow, are now employed as compensating machines on the three-wire lighting circuit of the Midland Railway Station at Derby, and similar machines are in use in other places for the same purpose. In his British Association Paper, Mr. W. B. Sayers explains the mode of action of these compensators, in balancing the disturbance of

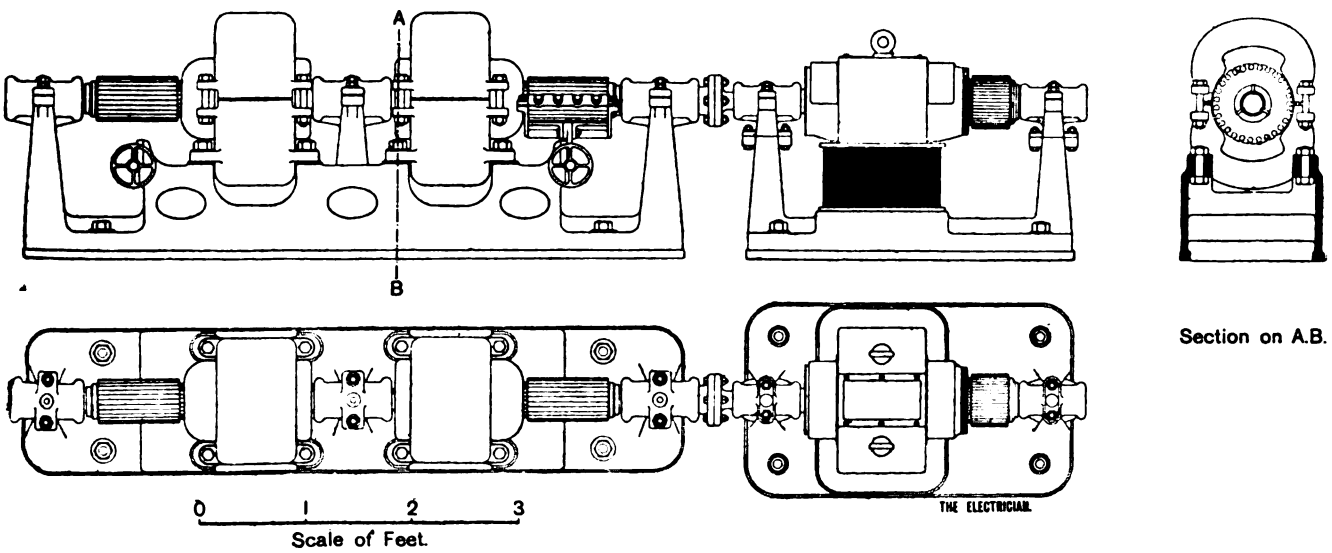

Fig. 1.—Elevation, transverse section, and plan of Sayers' Three-Wire Compensator.

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pressure-equilibrium at the feeding points, which is caused by upsetting the equilibrium of the loads on the two sections of the three-wire system.

Mr. Sayers arranged a diagram (Fig. 2) which illustrates the nature of the disturbance. In order to make it clearer he has taken an extreme case, and supposed there to be double as much current flowing on one side as on the other, so that half the total current (200 amperes) is returning by the balancing wire, which is supposed to have a cross-section equal to one-half that of either of the outer feeders. Under these conditions, if the feeders have the resistances indicated in the

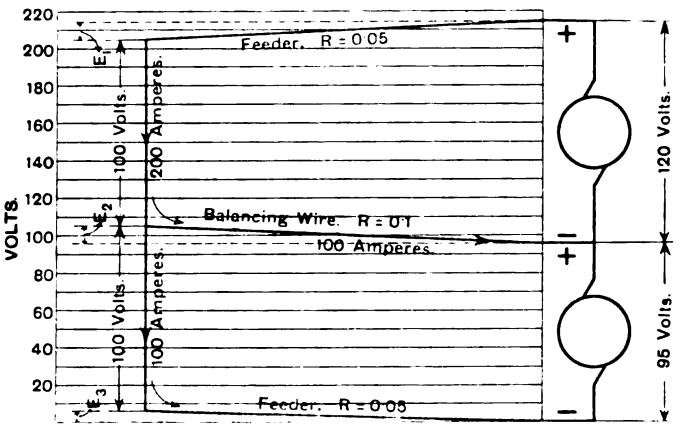

FIG. 2.

E_1 = Fall of Pressure in Positive Feeder = 200 × 0·05 = 10 volts.
E_2 = do. Balancing do. = 100 × 0·1 = 10 volts.
E_3 = do. Negative do. = 100 × 0·05 = 5 volts.

diagram there will be a fall of 10 volts both in the feeder and also in the balance wire as regards the overloaded side; but the fall of 10 volts in the balance wire counts as a rise of 10 volts as regards the underloaded side; and as the fall in the feeder on the underloaded side is only 5 volts it is clear that the generator on the underloaded side must only give 95 volts, in order that the pressure at the distant end shall be 100 volts, whereas the generator on the overloaded side must give 120 volts to secure the normal of 100 volts at distant end. On referring again to Fig. 2 it will be seen that the compensator through which the current to the feeder on the overloaded

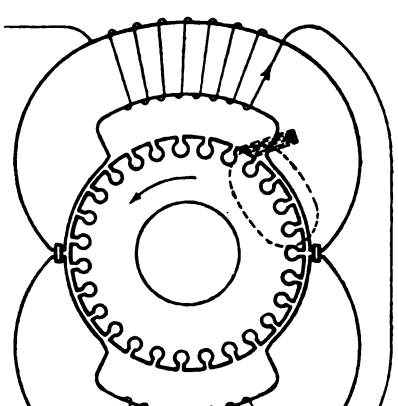

FIG. 3.

side passes must raise the pressure 20 volts, while the compensator through which the current to the underloaded feeder passes must *lower* the pressure 5 volts, the main dynamos being kept at constant pressure of 100 volts. It therefore follows that the compensator must be capable of running sparklessly, not only when the magnetic induction through the armature and keepers is proportional to the current flowing, *i.e.*, the ordinary conditions of a series machine, but also when there is a current through the armature, but no *effective* magnetic field or even a magnetic field in the opposite direction to what may be called the normal, so as to reduce the pressure. It so happens that these machines fulfil these conditions to an almost perfect degree. Fig. 3 represents a section through armature and keepers of one of the machines constructed. Suppose a current flowing through the winding around the keepers sufficient to neutralise or overbalance the effect of the current through the armature winding so far as the generation of E.M.F. is concerned, there will still be a considerable reversing field in the right direction due to the effect of the armature coils which are under the pole-pieces; or what is known as the cross-induction. This is indicated in one of the pole-pieces by the dotted line; the position of the brush is also indicated. The current in the balancing wire is made to assist this cross-induction in the machine which requires its E.M.F. to be raised, and to oppose it in the other machine, in which the voltage is to be lowered.

THE DEVELOPMENT OF ELECTRIC MACHINE TOOLS.*

BY S. S. WHEELER.

There can be no question that some mechanical engineers and electricians are far from convinced that it is desirable to modify the form of the tool so as to admit of a blending of the two elements in one. Many able engineers think it is well enough to bring the power cheaply and conveniently to the tool, but they then prefer to keep separate the motor and the driven mechanism. In traction there are some authorities who are wedded to the old practice of having the motive power in a freely detachable engine, while, as a matter of fact, a marked tendency in all the successful traction work by electricity has been toward having the motive mechanism in each car, and I do not overstate the case when I say that almost all distribution of power in the future promises to be done on the same principle. Be this as it may, it has seemed to my associates and myself that we realised the highest efficiency, economy, and flexibility in embodying our power within the tool, so that each tool might itself be fairly called an electric motor. It will, perhaps, be remembered that early this year our motor shops were transferred to Ampère (N.J.), and it is there that the tools now under consideration have been installed. If we were not satisfied with them we knew that nobody else would be, and we were perfectly satisfied to find out the difficulties ourselves, and solve the new problems that inevitably spring up rather than leave our customers to doubt our judgment because we had been led by enthusiasm to put some imperfect novelty on the market. Unfortunately, that happens too often in electrical development. Before proceeding to the descriptions, I pause simply to note the readiness with which these ideas have been applied. For example, as one result of the accident to the propeller shaft of the "Umbria," it has been influentially urged that as every steamer has an electrical plant it ought to carry electrical machine tools ready at a moment's notice, and able to go into a very small space. It is said that, with a portable electric drill for instance, the holes in the "Umbria's" shaft could have been bored in one-fifth the time that was actually consumed, and with infinitely less trouble. Anyhow, it is obvious that a self-contained electrical machine tool is much handier than would be two sets of mechanism to do the same work under the same circumstances.

I have already said that these tools were all built for the new works of the Crocker-Wheeler Electric Company, where the electrical method of distribution and driving has been broadly introduced. As the main line shafting, about 1,000ft. in all, previously in use in these works was removed as a preliminary to their occupancy of the property, it became necessary when moving there to make provision for the electric driving of the ordinary belt-driven tools from the old shop, or at least of such of them as could be equipped with advantage. A few, chiefly lathes, were belted in groups of five to single lengths of shafting, driven by motors bracketed to the columns of the building. In these cases the shafts were placed end to end in line, so that they could be coupled in pairs, threes, &c., in case it was found that larger divisions were more economical in driving. So far this has not been found desirable, on account of the greater flexibility of the present arrangement. The greatest difficulty in the introduction of motors on tools is due to the wide range of speeds met with in different tools, which is made still worse by the fact that almost without exception all industrial devices have been designed, improved, &c., solely with reference to belting, its conditions and limitations. The writer is strongly impressed with this, from experience so far had, in specially designing a few electric tools. But this is entirely

* Abstract from the *Electrical Engineer* of New York.

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overcome, and in each case several important advantages are secured, by starting at the bottom in design, and making a machine with reference to the high, quiet speed of the motor spindle. That is to say, in most cases more difficulties have been met and provided for, in designing and developing a given belted machine, say a profiler, in making a frame and bearings to stand the strain of the belt, in carrying the belt to the *travelling* tool, and in gearing up for sufficient tool speed, than would be the case in building one for a motor where the cutter holder can carry the motor and there are no strains or jerks. The speed-increasing gearing would simply have to be reversed, permitting the motor to run faster than the tool, instead of slower as in the case of the belt. And yet if we are compelled to start with a profiler already built, it is not easy to get the full advantages of simplicity in driving by motor to which we are entitled, just because the speed ratios of the gearing are opposite to what is now required, and everything is arranged for belts. In the case of other tools other features of a similar nature require changing.

A surface grinding machine, used in sharpening armature and other dies, was operated by two independent belts from an overhead countershaft; but when, by the removal, electric power became available in all parts of the shop, the countershaft was done away with, and a ¼ H.P. constant speed motor was mounted directly on the sliding carriage which supported the grinding wheel, and whose cross-wise sliding motion carries the wheel to all parts of the surface to be ground. A light belt was run from the grinding wheel under two idlers to the motor pulley, and as the motor was light enough to move with the carriage, it became possible to avoid the use of a pulley with long face equal to the total motion of carriage, across which the belt travelled when the carriage moved, which was formerly required on the countershaft. The motor is supported by four bolts with check nuts, by means of which it can be raised or lowered about half-an-inch, to keep the belt at proper tension. The power required by this tool on the 110-volt circuit never exceeds two amperes, and is supplied to it by a twin conductor. Four gang drill presses were formerly driven by belts from overhead countershafts, the belts coming directly down, then turning in a horizontal direction by the means of two idle pulleys attached to the top of the press, and thence passing around a driving pulley on a vertical shaft at the back of the press, which shaft carries four smaller pulleys operating the spindles by means of four short belts, in the usual way. The driving pulley on the upper end of this vertical shaft was removed, and a motor armature slipped on in its place. The field-magnets and regulator for the motor were then fastened to the drill-press frame, completing the machine. By this means the driving power was applied directly to the back spindle of each drill-press, saving at least one-half of the power formerly required. In these machines the necessary changes of speed are effected by a switch, which throws the armature either on to the 110 or 220-volt circuit accordingly as a slow or fast speed is required, the fields remaining on the 110-volt circuit until the switch is turned entirely off, when the fields are disconnected. By this arrangement the simplest windings of motor without divisions of the field coils or series multiple switches, are made to give the required changes of speed running in either case with perfect efficiency. A common planer, built to be driven by one straight and one cross belt from a countershaft, is now operated by two short belts, neither of them crossed, from two motors placed on a shelf bolted to the top of the tool frame of the planer. This arrangement gives several new possibilities in the operation of a planer. The relative speeds of the forward and back motion of the platen can be regulated by simply turning the hand regulators of the respective motors, and the platen can be sent the whole length of the bed in either direction without being returned, by starting one motor without the other. The construction, however, was simply a make-shift to get the planer into operation quickly by the use of standard motors, and will probably be changed at convenience by the substitution of a single motor with a long shaft and two pulleys for the two belts. Since the momentum of the platen requires either a heavy armature or a fly-wheel to stop and reverse it, the effect at present is to slow the motors up momentarily and produce sparking. The drills were all formerly operated by belts from the ceiling to the countershafts attached to the base plates of the presses, from which the power was transmitted by short belts to other shafts at the top of the presses, and then by bevel gears to the drill spindles. The motors now used are supported on heavy yellow pine brackets clamped to the pillars of the presses about half way up, and the power is carried to the countershafts by short belts. On the side of each alternate truss are the three wires to which they connect and which are the main branches from the round copper rods running the length of the shop. The connections from the main bars to the branch cut-outs are made by flexible cables attached to brass clamps, similar to a lathe dog cut open on one side. The tails of these clamps drop the cables down about 3in. below the main bars, giving a clear space for crossing the other bars. At the same time the clamps furnish a ready means of making firm connection to the bars after the latter are in position. These main shafts are half-inch round copper rods in straight 20-foot lengths, joined with cylindrical or sleeve couplings soldered, the rods being attached to the under side of a line of wide planking by the largest size of porcelain hook insulators. The three rods on the right hand in the view, serve to supply either 110 or 220 volts, at all points in the shop, thus furnishing a means of running at a fast or slow speed without regulator boxes, except for small intermediate gradations. The two lines on the left are heavy insulated wires for lighting. In addition to this set of circuits, which extends throughout all parts of the main and subsidiary buildings, another set of about as many conductors runs from the engine-room to the testing room. These test bars are branched off in four directions and brought down the four sides of the room, and are again branched and carried lengthwise under every bench, so that all the different voltages and special variable circuits are available at all points in this room. The conductors at all points of branching are carried in the same relative positions and the cross-overs are made at different levels about 6in. apart, each rod being carried to a point directly under the one to which it is to be connected, and soldered into the lower end of a rectangular brass piece, the upper end of which surrounds the corresponding rod. A large drill, built especially to be operated by a motor, has the motor mounted on a cast-iron bracket, forming the cap of the drill column, thus taking the driving power out of the way of the swing of the drill arm, the countershaft having formerly been located on one side at the base of the column. The fact that by this construction it is possible to swing the drill and arm around the entire circle was taken advantage of, to make the bed-plate of the drill-press circular, so that work could be set up on all sides. After a single reduction by gearing, the motion of the horizontal shaft of the motor was communicated to either of two vertical shafts by means of a pair of bevel gears. One of these shafts carries a gear which slides the length of the shaft, following the motion of the swinging arm when raised and lowered, and which gear drives a shaft extending out the length of the arm, upon which shaft another bevel gear slides and gears with the vertical spindle carrying the drill. Another gear near the drill connects with the horizontal shaft on the arm to drive the feed mechanism. The second vertical shaft is used to raise and lower the entire swinging arm with the drill and feed mechanism, a matter requiring considerable power. When this arm is to be raised or lowered, the motor is thrown into gear with this shaft by swinging the intermediate gear away from the other shaft and into gear with it, in the same manner as the lever and back gears on a lathe are operated. If the arm is to be lowered, the direction of rotation of the motor is reversed by the reversing regulator. In the final tests of this tool at the shop a man sat on the end of the swinging arm and rode up and down with the drill. The motor used is a 1 H.P. Crocker-Wheeler standard machine.

These examples of some of our latest work will enable the reader to form a conception of the lines upon which we are working and which we believe to be fundamentally sound. The argument is that it is better to take the tool to the work than bring the work to the tool; that it is better to have the tool self-contained so that by attaching to the copper mains it is at once ready to run at maximum efficiency. In our own shops this has certainly proved true in the manufacture of machinery that does not run into excessive sizes; but it must be even more true when we consider how bulky and heavy much of the modern machine work is. Units that we all thought gigantic have come to be small, no matter what the industry is; and in order to get the various parts treated, shifted to and fro, and assembled, shops have spread out acres wide and miles long, whereas the greater availability of these electrical machine tools makes for the highest concentration of effort and the smallest area of valuable real estate, combined with the utmost utilisation of every watt that the central power plant sends out.

QUEENSLAND AND THE NEW CALEDONIA CABLE.

The following extracts on the above subject are from *The Times*:—

The Société Française des Télégraphes Sousmarins, under contract with the Governments of France, Queensland, and New South Wales, which have guaranteed a subsidy of £12,000 a year, has just completed the laying of a submarine cable between New Caledonia and Queensland.

Sir George Dibbs (the Premier of New South Wales), in the course of an interview, defended the construction of the Queensland and New Caledonia cable, declaring that it would be useful in many ways, and especially in the event of war in the South Seas. He agreed that it was necessary that the Pacific cable of the future should be under British control, but insisted that New South Wales was still at liberty to co-operate in any such undertaking. He considered that the construction of the cable to New Caledonia should show the British Government the necessity of laying a cable across the Pacific *vid* New Zealand, Fiji, Samoa, and Honolulu.

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The Marquis of Ripon, in reply to the letter addressed to him on the subject by the Hon. J. B. Patterson, Premier of Victoria, expresses his regret at the action of Queensland and New South Wales in committing themselves to the laying of a cable to New Caledonia to serve as the first section of the proposed British cable across the Pacific to North America. The Secretary of State points out that this action is at variance with the views expressed by the Colonial Conference held in 1887, and lessens the chances of those Colonies which are assisting in the scheme of laying an entirely British Pacific cable. He concludes by stating that he shares the opinion of the Victorian Government that a French section in the Pacific cable might become a source of danger to Imperial and Colonial interests in time of war.

The laying of the first section of the Pacific cable, which was begun at Gomen, in New Caledonia, on August 30th, has now been completed to Bundaberg, one of the most flourishing centres of the sugar industry in Queensland, and French and English territory in the Southern seas are in telegraphic communication with each other. The cable has been laid on an entirely new line of soundings, and is reported to have found excellent resting and good bottom throughout the whole length of its course. Even the unexpected obstacle of a submarine mountain some 7,200ft. in height, which was discovered to exist upon the course originally selected, appears to have caused no serious difficulty or delay, and M. Rouilliard, the engineer-in-chief of the French Company, has received warm congratulations upon the manner in which the work of the expedition has been carried out.

It is hoped and believed by the Colonial supporters of the new line that it is a *bonâ fide* beginning of a Pacific cable which is to connect Canada and Australia, and complete the telegraphic circle of the world.

Queensland, which has always refused to subsidise the Eastern Extension Company's cable, on the ground, as has been generally supposed, of an old grudge hardly worthy of such long remembrance, has urged, in justification of her policy, that she desired to hold her subsidy in reserve for the encouragement of an alternative line, and New South Wales has now joined her in undertaking with the Government of France to guarantee the working expenses of the portion of the line which has been made. The course which the further construction of the cable is intended to take is—first, from New Caledonia to Fiji, then from Fiji to Samoa, from Samoa to Honolulu, from Honolulu to the Fanning Islands, thence boldly to Vancouver. The native rulers of the islands which are to be touched have promised substantial subsidies. The assistance of the Canadian Government is confidently counted on if the construction of the section from Honolulu to Vancouver should be brought within any measurable distance of fulfilment, and the advocates of the scheme do not despair of inducing the Governments of the other Australian Colonies which have hitherto resolutely opposed it to contribute to the guarantee. There can be little doubt that the existence of a Pacific cable connecting the eastern and western limits of the Empire with each other would be an advantage from every Imperial and Colonial point of view. There are, nevertheless, good reasons for the coldness with which the present scheme has been received by Victoria and the other Australasian Colonies which have refused with her to contribute to the guarantee. The Société Française des Télégraphes Sousmarins is a foreign company subsidised by a foreign Government. The proposed route of the cable lies in part through foreign territory. The principal value of a cable from the Imperial point of view is for political purposes, and it is evident that a line which passes at any portion of its course entirely into the hands of a foreign Power might become perfectly useless in the event of complications arising with that Power. It is not probable that any English Government would be disposed to contribute to the guarantee of a French cable, and in the absence of an Imperial guarantee it is not easy to foresee how the financial difficulties attendant upon the construction of the immense stretch of line from Honolulu to Vancouver are to be surmounted. The business to be transacted between the four and a-half millions of Australia and the communities with which the proposed cable would bring them into connection does not seem likely for many years to justify the construction of the line as a purely commercial undertaking. There can be little doubt, however, that the development of communications does stimulate as well as follow trade. The establishment of new lines of steamers has always been the forerunner of the construction of submarine cables, and if the new cable should, notwithstanding anticipations to the contrary, succeed in establishing itself upon a commercial basis, the result would be wholly a matter for congratulation to every one concerned.

TO THE EDITOR OF "THE TIMES."

SIR: It is a striking illustration of the indifference of the so-called Imperial Parliament to Imperial interests that such an obvious, urgent, and necessary Imperial requirement as a telegraphic service entirely under British control, connecting Great Britain with British North America and our Australasian Colonies, still continues to be practically ignored and neglected, notwithstanding the prominence and importance assigned to it in the deliberations of the Imperial Conference held in London in 1887. Is it not something in the nature of a national humiliation that the first section of a cable from Australia to America—Queensland to New Caledonia—should have been just completed by a French company subsidised by the French Government and the Governments of two of our own Colonies, New South Wales and Queensland? To find ourselves forestalled by a foreign Power in an enterprise that one glance at the map of the world is sufficient to show ought long ere this to have been undertaken by our own Imperial action and resources is a most unwelcome and regrettable experience. Sir George Dibbs, the Prime Minister of New South Wales, is represented in your issue of to-day as defending the alliance of his colony with this foreign enterprise on the ground that it will bring business to the Australian land lines. No doubt it will; but is it wise, patriotic, or statesmanlike on the part of an Australian Premier to materially assist in the strengthening of a foreign foothold in Australian waters? Sir George thinks that the frequent escapes of French prisoners from New Caledonia to the shores of Australia will be checkmated by this new cable service. As there are good grounds for believing that these repeated escapes are too often connived at by the New Caledonian authorities, I do not think Sir George will find many to share his sanguine anticipations in this respect. He also hopes that the construction of this foreign cable will stir up the Imperial Parliament to the necessity of establishing without further delay a new cable service across the Pacific entirely under British control. But will it? I believe that we shall one day have to pay dearly for our apathy in this important matter; and that the time will come when overpowering reasons of Imperial policy will compel us to acquire this foreign cable service at a price that will be enormous in comparison with what it would have cost to construct a Pacific cable at our own expense during the years that we have been idle while our foreign competitors have been at work.—Sincerely yours,

October 17th. J. F. HOGAN

SPARKING DISTANCES IN PARAFFIN.*

BY DR. V. MONTI.

The results obtained by A. Macfarlane in 1877, when investigating the difference of potential necessary to pierce a layer of paraffin of given thickness, are criticised by Dr. Monti in the Paper before us. Dr. Macfarlane had found that for a thickness of 3mm. a difference of potential of 39,000 volts was sufficient. This is about double that required for air, and far below the values obtained by C. P. Steinmetz and by Dr. Monti himself.

The paraffin used by the latter liquefied at 54·76deg. The terminals were brass balls of 3mm., 5mm. or 8mm. diameter. Two balls of the same diameter were mounted inside a glass tube 25mm. thick and 10cm. long. Their distances apart were measured by means of a microscope fitted with an eye-piece micrometer. After that the paraffin was brought to a temperature a little above its fusing point, and allowed to solidify in a partial vacuum of 100mm. It was then fused again, and allowed to solidify in air. In this manner the formation of air bubbles between the terminals was avoided.

The method employed for determining the necessary difference of potential was that of equivalent sparks, in which the thickness of paraffin pierced was compared with the corresponding thickness of air. As the result of all the series of measurements, it may be said that to discharge across a layer of paraffin 1mm. thick, between knobs 5mm. in diameter, requires a difference of potential of 155,000 volts. According to Freyberg, the corresponding difference of potential for air under the same circumstances is 5,050 volts.

Dr. Monti explains the difference between Macfarlane's results and his own by the probable presence of air bubbles in the paraffin in the former case. It would, in fact, be well-nigh impossible to avoid them when allowing the paraffin to solidify between two walls 3mm. apart.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October* 6, 1893.

American Institute of Electrical Engineers.—The subject of local meetings of the American Institute of Electrical Engineers is now being discussed, and it is probable that some action will be taken in the near future. A plan viewed with favour is to have advance copies of the Institute Papers sent to several localities where there is a considerable membership, to be read and discussed there as at present before the main body of the Institute. Adjunct members, or *auditeurs*, not regular members of the Institute, will be permitted to be present at the local meetings and take part in the discussion; the discussion will then be edited by a local secretary, and forwarded to the author and be again edited by the Central Editing Committee before being admitted to the *Transactions*.

Prof. Von Helmholtz.—Prof. Von Helmholtz during his recent short visit received quite an ovation from the scientific circles of New York. A reception was tendered to him at Columbia College to which eminent men in all branches of science and public life were invited, and Prof. A. Graham Bell personally gave him an introduction to the recent achievements in telephony at the rooms of the Long-Distance Telephone Company.

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* *L'Elettricista*, October, 1893.

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CORRESPONDENCE.

WHAT ARE THE ADVANTAGES OF LOW FREQUENCY?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There may be others of your readers beside myself who are anxious to learn, but have difficulty in reconciling, the various statements that are made on the same subject. May I give an example in the hope of explanations ensuing. I observe in the course of a laudatory notice of the central station recently started at Derby that the rate of alternation adopted is 40 periods, and on seeking information from an authority I gathered that the only advantage in this low rate of alternation is that at present alternating motors run better on, or are more easily built for, a circuit of a low rate of alternation, but that otherwise, the plant is more expensive and less efficient. I also noticed in the report of a congress at Chicago that it was stated that "arcs are blotted out at from 40 to 50 periods," and that flickering can be detected in incandescent lamps at low rates; another speaker added that 35 to 37 periods was the practical limit, which seems somewhat adjacent to 40. Perhaps someone who knows will kindly explain whether the station will work inefficiently, or whether the speakers are wrong.—Yours, &c.,

London, October 17, 1893. T. M. W. W.

[Our correspondent evidently refers to some other account of the Derby station than the brief notice in our last issue. The information he has gathered is, we believe, quite correct. In connection with arc lighting on low frequencies, the flicker at Paddington Station, which when once noticed is very irritating, is due to the low frequency employed.—Ed. *E.*]

CARDIFF ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We beg to hand you copy of a letter, which we have addressed to the Borough Engineer of Cardiff, and which we think of sufficient general interest to bring under your notice.—Yours, &c., CALLENDER'S BITUMEN, TELEGRAPH AND WATERPROOF COMPANY (LTD.),

S. C. LAMBERT, Secretary.

101, Leadenhall-street, London, E.C., October 18, 1893.

101, Leadenhall-street, E.C., London,
October 16, 1893.

DEAR SIR: We beg to confirm the telegram sent you to-day as follows:—"Notice of your Corporation requiring tenders for cables only published in Friday's electrical papers. Tenders required to be sent in to-day, time manifestly too short. Will you grant extension? Please telegraph reply;" and have received your reply:—"Extension of time for receipt of tenders impossible."

Under these circumstances, we desire to lodge a formal protest against the method of inviting tenders which you have adopted, and the totally insufficient time which has been given to independent contractors to make their calculations and to prepare the necessary offers.

We have made inquiries, and find that your Corporation has not advertised in any of the Papers devoted to electric lighting, the notice to which reference is made in our telegram to you being taken from the Press outside the electric industry. We call your attention to the fact that this is the first contract for electric cables "advertised" by a Corporation, which has not been fully announced in the trade journals. The method you have adopted in inviting tenders precludes open tendering by independent manufacturers.

If your Corporation had decided to invite certain makers to a private competition we would have had nothing to say, but we distinctly protest against action such as has been adopted in the case of Cardiff being considered as a public invitation to tender.

We reserve to ourselves the right to make this letter public.—Yours faithfully, CALLENDER'S BITUMEN, TELEGRAPH AND WATERPROOF COMPANY (LIMITED),

T. O. CALLENDER, Manager.

W. Harpur, Esq., Borough Engineer, Town Hall, Cardiff.

[In answer to inquiries, we are informed from Cardiff that the announcement was sent to a London journal; but any similar unpleasantness would in future be easily avoided by the authorities at Cardiff adopting the usual course of selecting the established trade organs for such Advertisements. Our Correspondent's complaint cannot, under the circumstances, be considered unreasonable.—ED. *E.*]

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The Gas and Lighting Committee of the Bolton Corporation invite tenders for the supply and erection of switchboards, accumulators, connections, &c. Specifications, &c., can be obtained from Mr. J. H. Rider, the borough electrical engineer, and tenders must reach Mr. Alderman Miles, chairman of the above committee, at the Gas Office, Bolton, not later than Saturday, November 18th. Further particulars appear in our advertisement columns.

——— The Corporation of Sunderland invite tenders for the supply, in connection with their scheme of electric lighting, of (1) boilers; (2) engines, dynamos, pumps, steam pipes, &c.; (3) motor alternators, switchboard, &c.; (4) main switchboard, instruments, and connections; (5) batteries; (6) insulated cables, &c.; (7) supplying and laying culverts, &c.; (8) copper strip; and (9) gun-metal grip boxes. Persons or firms wishing to tender for any of the above contracts must send their names and addresses to the Borough Engineer, Town Hall, Sunderland, from whom drawings, specification, and forms of tender are to be obtained. Tenders must be addressed to the Chairman of the Highways Committee, and be sent in to the Town Clerk's Office, Sunderland, on or before Friday, November 3rd. Further particulars appear in our advertisement columns.

IMPROVER WANTED.—The Corporation of Hull notify in our advertisement columns that they are prepared to take an improver into their electric light works for a period of two years. Applications must reach Mr. Alfred H. Gibbings, the borough electrical engineer, by 10 a.m on Thursday, November 2nd.

CHANGE OF ADDRESS.—Messrs. Woodhouse and Rawson United (Limited) inform us that on and after November 11th the address of their Glasgow branch will be 12, West Campbell-street, where they are moving to larger and more convenient premises.

LIQUIDATIONS.—It is announced that Mr. Stewart Bogle, A.C.A., of Copthall-avenue, E.C., has been appointed liquidator of the London Metallurgical Company (Limited).

BANKRUPTCY.—Notice is given that Mr. Gourlay, C.A., of 24, George-square, Glasgow, has been elected trustee on the sequestrated estate of Messrs. J. and W. Weems, of Johnstone, Scotland, and of Mr. Alexander Wylie, of the same address, sole partner. The examination of the bankrupt will take place in the Sheriff Court House, Paisley, on Wednesday, 25th inst., at 12 noon; and the second general meeting of creditors will be held at the chambers of Messrs. Thomson, Jackson, Gourlay and Taylor, 24, George-square, Glasgow, on Friday, November 3rd, at 11 o'clock. Creditors to be entitled to the first dividends must lodge their oaths and grounds of debt on or before January 28th next with Mr. J. Gourlay, the trustee. Affidavits already lodged do not require to be repeated.

PRESENTATION.—The recent marriage of Mr. Rashleigh Phipps was on Friday last made the occasion by the employés of Messrs. Rashleigh Phipps and Co. for the presentation of a handsome marble clock and an illuminated address, which was followed on Wednesday last by a dinner to the employés under the presidency of Mr. Snowdon, the general foreman.

THE FOWLER-WARING CABLES COMPANY (LIMITED).—This Company is now represented by Mr. Alfred E. Garbutt in the north of England; by Mr. J. Vincent Swindells in Manchester and Midlands district; and by Mr. Charles Parker in the Eastern and South-Eastern districts, including London. Offices will shortly be opened in Newcastle as the centre of the Northern district, and in Manchester as that of the Manchester and Midlands district.

A T-SQUARE ATTACHMENT.—Mr. J. P. Maginnis, the inventor of numerous drawing instruments and appliances, is introducing an attachment for an ordinary T-square, which gives all the advantages of a movable head. One use of such a square is in making additions to a drawing. The drawing may be pinned down to a board without reference to the T-square; and a correct adjustment may be immediately obtained.

THE "HARD" INCANDESCENT LAMP.—Messrs. Wilhelm and Co., of 132, Wool-exchange, E.C., notify us that they have been appointed representatives in this country of the "Hard" Incandescence Lamp Company, of Zürich, and are prepared to supply the lamps manufactured by that firm after November 10th next. Messrs. Wilhelm and Co. issue printed particulars concerning the Hard lamps, which can be obtained on application. They are intended for "3½ watts per candle, and a mean duration of 800 to 1,000 hours."

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STORAGE BATTERY PATENTS ABROAD.—Judgment was pronounced on Wednesday at Frankfort-on-the-Main against the plaintiffs in the action brought by the Electrical Power Storage Company (London) against the Pollak Company, the proprietors of the accumulator works in that city, to restrain the latter from manufacturing or selling accumulators. This is the first time that a German court of law has given a different decision from that pronounced in similar actions against other accumulator manufacturers preferred by the actual patentee—the Accumulator Manufacturing Company of Hagen.

HARD FIBRE.—We have received samples of the Delaware Hard Fibre Company's manufactures from their agent, Mr. J. Burns, 15, Long-lane, E.C. In addition to use for pump valves and other mechanical purposes, for which it appears to be excellently suited, it is claimed that this material is an insulator of electricity. We have examined the samples, which closely resemble ordinary red vulcanised fibre, and find that, like that material, so long as it is quite dry, the insulation of the hard fibre is good, but falls off in the presence of moisture, which is readily absorbed.

MESSRS. SIEMENS BROS. AND CO.—We have received from this firm a copy of a new price list just issued of Siemens dynamos, which contains illustrated particulars of the various types of machines manufactured by Messrs. Siemens Bros. Included in the list are a number of carefully compiled tables, from which full information can be gathered respecting output, weight, dimensions, prices, &c. The information given as to the actual cost of machines and spare parts is very complete.——Messrs. Siemens Bros. also announce that on and after November 10th they will be prepared to supply the Siemens and Halske incandescent lamp in this country.

MESSRS. NALDER BROS. AND CO.'S PRICE LIST.—We have received a very complete and admirably illustrated price list of the electrical testing, mathematical, optical, and other instruments made by this firm. Among the new apparatus in this, the fifth edition of the catalogue, we find a large variety of standard cells, among which the Carhart-Clark cell is recommended, Messrs. Nalder Bros. and Co. are the sole makers in Europe. The Carhart modification of the Helmholtz cell gives 1 volt with a temperature coefficient of only 0·009 per cent. per degree centigrade. New electrometers and galvanometers are illustrated, including Dr. Lodge's pattern for physiological work. For small alternating currents a torsion galvanometer is made. Prof. Anthony's form of Wheatstone bridge is included, and among a variety of large resistances we find coils of 100 ohms to carry one ampere, manganin standards of the Reichsanstalt pattern, and potentiometers. Messrs. Nalder's new optical department and the extensometers, cathetometers and clocks, appear to fully maintain the high standard of their electrical apparatus. The list is provided with a useful telegraphic code.

BARROW.—At the meeting of the Town Council last week it was decided to apply for a Provisional Order empowering them to supply electricity within the borough.

BECKENHAM.—The Local Board have approved the conditions under which the Crystal Palace Electric Lighting Order is to be carried out in their district.

BELFAST.—An order of the Privy Council prohibits the inspection of cattle at the harbour after sunset, but an agitation has been started to have an electrically-lighted depôt where such inspection may take place, so as to do away with the present delay and inconvenience.

BIRKENHEAD.—Some months ago the Town Council appointed a sub-committee to consider the best means of carrying out the provisions of their Electric Lighting Order, and Mr. Shoolbred and Dr. J. Hopkinson were requested to report thereon. These gentlemen have now presented their reports, and they state that, whilst no great difficulty would be met with in doing the work, the straggling character of the district would render the cost rather considerable, the estimates ranging, according to the scheme proposed, from £15,000 to £40,000. The sub-committee think it advisable to have personal interviews with Mr. Shoolbred and Dr. Hopkinson, and the whole question will shortly be considered by the Corporation.

BOLTON.—The Local Government Board have given their sanction to the loan of £40,000 in connection with the supply of electricity, and have given consent for the Corporation proceeding with the erection of the works.

BRADFORD.—The Gas and Electricity Supply Committee of the Town Council have had under consideration the desirability of lowering the charges for electric current used for motors during the day-time, and a sub-committee was appointed to deal with the subject.

BUXTON.—Some time ago the Local Board appointed an Electric Light Committee to inquire generally into the subject of lighting the town, and inquiries were made at the last meeting as to when they are likely to report.

CARRIAGE LIGHTING.—The Sherborne Electric Installation Company, of Sherborne, Dorset, are charging accumulators for the lighting of carriages and other vehicles made by Messrs. Hill and Ball, a well-known firm of carriage builders at Sherborne.

CHESTER.—There was an animated discussion at the meeting of the Town Council last week with reference to a recommendation of the Watch Committee that the Hop Pole Paddock be selected as the site of the central electric station. Notwithstanding the telegraphed opposition of the Duke of Westminster, the Town Council decided by a large majority to adopt the site.

DEWSBURY.—The Board of Guardians, at their meeting on Friday, resolved to give their Electric Lighting Committee power to consult an electrical engineer in respect to the scheme suggested for lighting the new infirmary and the workhouse. The estimated cost is about £2,100.

DOUGLAS (ISLE OF MAN).—The Town Commissioners have received from Mr. G. T. Pardoe, of Manchester, two approximate estimates of the cost for hydraulic electric light stations; but it was stated at a recent meeting of the Commissioners that the Health Committee had under consideration a scheme for the better lighting of the town, and it was decided that meanwhile they could not deal with Mr. Pardoe's offers.

EALING.—It is feared that the works in connection with the installation of the electric light will be somewhat delayed, in consequence of no official inquiry having yet been held by the Local Government Board into the application made by the Local Board for sanction to borrow the amount (£25,000) required for the purpose of the scheme. The Local Government Board have intimated that the inquiry will be held as soon as the engagements of the Inspectors permit.

ELECTRICITY IN LAUNDRY WORK.—At Exwick, Devonshire, some large premises formerly used as flour mills have been taken over by a steam laundry company. The machinery is driven by the old mill waterwheel, which also drives the 80-light dynamo which lights the whole building with electricity. Electrically-heated irons, including a Mirror collar ironer, are used.

ELECTRIC TANNING.—Mr. L. A. Groth has introduced his electric tanning system at Orbe, near Lausanne, with success. He informs us that the largest tanyard in this place is being reconstructed according to the "Groth" system.

THE ELECTRIC LIGHT IN MILLS.—One of the largest electric light installations for corn mills is being fitted up at the Mersey Rice and Flour Mill at Liverpool. The installation comprises two 400-light dynamos and storage for 400 lights, together with a separate engine and dynamo for lighting the mill in the day-time.

FRANKFORT-ON-THE-MAIN.—The Municipality have adopted a proposal of the Executive Department for the erection of a central electric light station. The installation will be according to the plans submitted by Messrs. Miller and Lindley, and will be on the alternate-current system with transformers, and a low-pressure distribution. The dynamos will be constructed by Messrs. Brown, Boveri and Co., of Baden, Switzerland, and the cables will be supplied by Messrs. Felten and Guillaume, of Cologne.

GALASHIELS.—The Town Council, at their last meeting, had under consideration a request of the Caledonian Electric Supply Company for consent to apply for a Provisional Order to supply electric light in the burgh, but after a lengthy discussion a decision was adjourned to a special meeting, at which the subject could be more fully explained.

GLASGOW.—With respect to the Trade Note last week under this heading, Mr. Arnot requests us to state that the report he is preparing is not on electric haulage, but on the lighting of the tramcars.

GRIMSBY.—The Lighting Committee of the Corporation have decided to recommend the Council to apply for a Provisional Order, and meanwhile have appointed a sub-committee to take charge of the matter.

THE GUILDHALL.—The City Lands Committee recommend the City of London Corporation to extend the electric lighting to the art gallery at an estimated cost of £290.

HALIFAX.—The electric lighting of Halifax is at present provided by a private company, but as the Corporation some time ago decided to take in hand the question of electric lighting for the town, the local company have decided to stop business on the 18th of next month. A deputation of tradesmen last week waited upon the Electric Lighting Committee of the Corporation requesting them to make arrangements to continue the supply until the Corporation works are ready. The Committee, however, were unable to give a favourable answer to the request, and it seems likely that those tradesmen who have the electric light fitted up will have to fall back on gas in the interval. We understand that the Electric Lighting Committee are in negotiation for the purchase of a site for the central station.

HEREFORD.—At the last meeting of the Herefordshire County Council the County Surveyor reported that he had gone into the

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matter of the proposed lighting of the Shire Hall by electricity, and he found that owing to no facilities existing for obtaining the requisite motive power at a reasonable cost, the capital expenditure for providing such power, with the necessary cables, wires, dynamos, lamps, &c., would be so great that he could not offer any recommendation. The report was adopted.

HEYWOOD.—Consent has been given by the Local Government Board to the Corporation borrowing £3,500 for machinery and electric lighting at the sewage works, to be repaid in ten years.

KILLARNEY.—The electric light or gas lighting for the town was the question on which the recent municipal election was fought, and in the result the advocates of the newer illuminant were successful, which we hope will terminate the deadlock that has occurred with regard to the lighting question.

LEEDS.—The Highways Committee of the Corporation last week decided to renew the lease of the Thomson-Houston Company's overhead electric tramways to Roundhay Park for six months, after which time the lease will be renewed for periods of one month at a time, until some final arrangements be arrived at.

NEWPORT (MON.).—The Town Council at their last meeting had under consideration the preliminary report of Mr. Hammond upon the proposed electric light installation. The site suggested for a central station is in Friars Fields, and the estimated expenditure, including the mains, is £25,000. The Council empowered the Sub-Committee to request Mr. Hammond to proceed with the preparation of the detailed plans and specifications, in order that tenders may be obtained at the earliest possible date. It was also decided to apply to the Local Government Board for permission to borrow the amount required for an electric light installation.

PAIGNTON.—It was stated, at the last meeting of the Local Board, that further offers had been received from firms for the electric lighting of the town, and it was resolved to appoint a special committee to consider the whole subject and report.

PLYMOUTH.—The Corporation have decided to apply for a Provisional Order authorising them to supply electricity within the borough.

PORTSMOUTH.—Everything is progressing favourably with the electric light installation, and Alderman Ellis and the Committee hope to have it complete by Christmas. The work of laying the mains beneath the streets and pavements is proceeding with rapidity, and in the course of a few days the cables will have been drawn through the conduits.

ST. PANCRAS.—The West St. Pancras Ratepayers' Association have passed a resolution to the effect that, while heartily approving of the electric light, they were desirous of impressing upon the Vestry the necessity of improving the lighting in the upper part of Park-street. One of the speakers said that the light was not nearly so good as the superseded gas light.

SHANGHAI.—The plant and business of the New Shanghai Electric Company (Limited) were acquired by the Shanghai Municipal Council on September 1st last. The Electrical Department has been placed in charge of Mr. Charles Mayne, the municipal engineer.

SHOREDITCH.—At the last meeting of the Vestry a report was brought up from the Electric Lighting Committee, stating that they had considered the reference back to them of their report of the Pitfield-street site, with instruction to make a further financial statement and report. So far as the electric lighting scheme was concerned, they considered the report of Mr. Manville contained the fullest financial information that could be afforded until a site had been actually acquired. With regard, however, to the dust utilisation part of the scheme, and the amount of heat which would be available for baths and washhouses and motive power, the Committee thought it would be advisable and very useful in a scheme of this magnitude to obtain a financial report from Messrs. Manlove, Alliott and Co. The Committee had accordingly instructed them to report what results they could guarantee with regard to the cost of burning 20,000 tons of dust per annum, and the amount of heat which would be available for baths and washhouses and electric lighting purposes, and the capital cost of maintenance, for the sum of £10. 10s. The Vestry approved the action of the Committee.——Mr. W. T. Baker, of 25, Wormwood-street, has forwarded to the Vestry plans of a new scheme for the erection of baths, electric lighting station, and dust destructor, which have been sent to the Electric Lighting Committee and the Baths and Washhouses Commissioners. Mr. Baker claims that his scheme would be self-supporting.

SOUTHEND.—The Corporation have empowered the Highways and Works Committee to invite offers for the undertaking and carrying out of the Corporation's Electric Lighting Order.

TAUNTON.—The Town Council have decided to purchase for the central station an additional boiler from Messrs. Davey, Paxman and Co., at a cost of £380, and a steam drum from the Babcock-Wilcox Company (Limited), at a cost of £30.

WARMINSTER.—The Local Board have had several communications from electricians in London in reference to the question of lighting the town by electricity, and the matter is now being considered.

WESTON-SUPER-MARE.—A sub-committee of the Town Commissioners has been appointed to consider the subject of lighting the town by electricity.

WINDSOR.—Councillor Dyson had given notice of his intention to move at the last meeting of the Town Council—"That this Council request the Board of Trade to revoke the Provisional Order granted to the Windsor and District Electric Lighting Company; that the Council do apply to the Board of Trade for a Provisional Order for Windsor and Eton, and that a Committee be formed, to be called the Electric Lighting Committee, to consider the whole question, and to report from time to time to the Council on the subject," but when called upon to move the resolution, he said that since he gave notice certain questions had sprung up which seemed to alter the phase of the whole thing; and he asked permission for the motion to stand over, which was agreed to.

WOOLWICH.—The Local Board of Health have requested the Lighting Committee to consider and report on the expediency of lighting Beresford-square with the electric light. The Baths Commissioners are considering the propriety of so lighting the public baths.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.

October 2, 1893.

18,386. E. W. LANCASTER. Birmingham. Improvements in electrical switches.*

18,392. W. W. G. WEBB. Crewe. Improvements in electric clocks and watches.

18,403. J. J. MANN. Manchester. Improved means of intercommunication by telephone.

18,404. J. J. MANN. Manchester. Improved means of intercommunication by telephone.

18,426. G. DRAPER and A. FRASER. London. Improvements in electric telegraphs and mechanism used in connection therewith.

October 3, 1893.

18,457. H. HAWKSEY. Manchester. Electrically lighted letters.

18,472. J. CROWSHAW. Manchester. Improved means of signalling upon railways.

18,475. A. M. THOMPSON. Crewe. Electric signals for railways.

18,480. M. RAHNER. London. Improvements in armatures for dynamo-electric machines and electric motors.*

18,482. J. OPPERMANN. London. Means for determining the presence and intensity of atmospheric electricity.

18,509. G. POLKEY. Birmingham. Improvements in signalling and other lamps.

18,524. J. R. BURNS and W. F. BURNS. London. Improvements in indicators, chiefly designed for use at telephone stations, also used for advertising purposes.*

18,530. SIEMENS BROS. AND CO. (LIMITED) and G. H. THORNTON. London. Improvements in the arrangement and connection of conductors for electric railways.

October 4, 1893.

18,564. I. A. TIMMIS. London. Improvements in staff apparatus for the working of a single line railway.

18,577. G. PALMER. London. Improvements in, and in apparatus employed in, galvanising tubes and bars.

18,586. L. ZAUSMER. Liverpool. An improved regulator for arc lamps.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

16,335. HARRISON. Electric telephone apparatus.

16,615. FROGGATT. Electric incandescent lamps.

17,653. LEHMAN. Electric batteries.

19,910. EBBUTT and VERITY. Reflectors for lamps and lights.

20,415. GENT and OTHERS. Microphones.

20,485. ROBSON and BROWN. Miners' safety lamps.

21,782. SIEMENS BROS. AND CO. (LIMITED) and NEBEL. Electrical resistance coils.

1893.

5,694. RICHARDSON. Electrolytic decomposition of solutions of chloride of sodium, &c.

13,888. WEISE. Electric current, &c., governors.

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COMPANIES' MEETINGS.

Brazilian Submarine Telegraph Company (Limited)

The fortieth ordinary general meeting of the shareholders of this Company was held at Winchester House, Old Broad-street, on Wednesday last, under the presidency of Sir John Pender, G.C.M.G., M.P.

The SECRETARY (Mr. Richard Collett) having read the notice convening the meeting, and the minutes of the previous ordinary general meeting, and the report of the Directors having been taken as read,

The CHAIRMAN said: Ladies and gentlemen, before beginning the business of this meeting, I may say that a name has just been mentioned (by the Secretary, in reading the minutes of the last general meeting) which has been long associated with this Company—that of Sir James Anderson. I was in the room at the last half-yearly meeting, when Mr. St. John Brodrick made his statement. At that time Sir James Anderson was lying in a very serious state, and since then he has passed away. We all deeply regret the loss of a very valued colleague, who was long associated with this Company—indeed, from its inception—and whose name will always be associated with the progress of submarine telegraphy. The world moves on, men pass away, but still the work of the world has to be done. As regards our Company, the work is being done. Probably my long association with submarine telegraphy is the reason why I am occupying this chair to-day. As you know, I have a fair amount of work to do, but telegraphy is probably an exception to almost every other business. It is one great chain, and every cable is directly or indirectly connected with the chain, forming a link in it, and, therefore, it is, above all systems of business, one which requires at its head somebody who may, more or less, have his eye on every link of that chain. The Brazilian Submarine Telegraph Company is one of those links—a very important link—and it has been a very successful link in the chain of submarine telegraphy. It has troubles to pass through at times when there is revolution here and there and almost everywhere; and while our system is principally connected with those places we have to keep a watchful eye over it, and to see that the system is kept up, and, to speak very plainly, that the dividends do not go down. I think we are probably in that position to-day. It is a position of some anxiety, but we have perfect confidence in the work which we have to do, in the value of that work, and in its importance in connection with political, social, commercial, and every other progress, for, more or less, this system is identified with such progress. In taking the chair of this important Company, in addition to those I already hold, I am simply taking the chair of another link, of another system, which, so far as we are concerned, has been a system successful alike to the public who use it and beneficial to the shareholders who are interested in it. Now, gentlemen, after those remarks—which, perhaps, I must almost ask your pardon for having made—I would say that all those who have taken part in this great industry, which has more or less revolutionised the world, are entitled to have the fullest information about it. You are also to be congratulated on the success which has attended your investment. I will now deal with the accounts of the last six months. The receipts for the half-year ended June 30, 1893, were £106,860, and for the previous half-year they were £113,892, showing a decrease of £7,032. As compared with the income of the corresponding half-year of 1892—namely, £111,870, the decrease is £5,010. The message receipts show a decrease of £7,290, while the miscellaneous receipts from interest, rents, and transfer fees result in an increase of £258, leaving the net decrease at £7,032. In the half-year under review we carried about 3,500 more messages with South America than in the previous six months, yet we realised about £7,290 less. This results from two causes—first, a reduction in the tariff of charges from April 1st last; and, secondly, a further reduction in the exchange value of the Brazilian silver currency, the value of the milreis having averaged in the half-year 12⅛d. as against 13⅜d. in the previous half-year. On the other hand, there are increases in the receipts from the traffic with the African Coast and Cape Colonies, transmitting through our St. Vincent station, of £500 and £130 respectively. The total expenditure for the half-year was £40,580, which, compared with that of the previous six months—namely, £24,536—shows an increase of £16,044. This very large increase results from quite an exceptional state of things. As reported at the meeting in May last, there had been several repairs of cables made, and the cost thereof appears in the accounts now before you. These operations included the renewal of all our shore ends at Madeira, four in number, with specially designed heavily armoured cable to resist the constant wear and tear resulting from the action of the tides and storms breaking on the rough beach where our cables land. There was also a repair of our first cable between Maderia and St. Vincent, in deep water, and of both cables between St. Vincent and Pernambuco, one near St. Vincent and one near Pernambuco. The cost of these operations, including the conveyance of spare cable to Maderia and St. Vincent, was £19,557. Now that is a large sum, but you must bear in mind in connection with submarine telegraphy that if you put new cable in you are strengthening your system generally. These repeated repairs usually result in a considerable addition of new cable, and that means a prolongation of the "life" of the original cable. I mention that in order to impress upon you that while we are expending largely, we are also prolonging the "life" of the cable itself. Of course, submarine cables do not last for ever, but if we are effecting repairs from time to time and introducing new cable where the original has become weak through some action which it is very difficult to comprehend, when the portion which has suffered by friction or by other causes—perhaps chemical causes at the bottom of the sea—has been removed, we are strengthening the system as a whole, and therefore while I have to mention this very large expenditure, for it is a considerable sum, I assure you that your cable is always stronger for it. The item of agencies shows an increase of £1,115, arising from prolonged negotiations with the Brazilian Government upon special matters, and from the employment of additional agencies upon the Continent. The other principal increases are in rent and taxes, &c., arising from the more energetic collection of taxes in Portugal and St. Vincent, £175; in maintenance of land lines and electrical expenses, £638, of which £344 is in respect of the cost of arranging for the duplex of No. 2 cable being adapted for application to No. 1 cable when wanted, and £294 is due to the renewal of land lines at Madeira and Pernambuco. There is a particular point which I should like to call your attention to in connection with this question of the duplexing of cables. This enables a cable which has cost a very large sum of money to carry telegrams both ways. It is an invention which has doubled the carrying capacity of submarine cables, although it has not doubled their value. It has, however, doubled their carrying capacity, and it is very doubtful whether we could to-day do the amount of work we have to get through without expending more money on the cables if it were not for this clever system of duplexing. This Company did not avail itself of this system in the early days, because, probably, it was not required, but latterly they had the advantage of all this duplication on the lowest possible terms, because before they adopted it the patents had practically expired, and there was not in your case that heavy payment for the duplexing which the other companies had to make. We are therefore now in the enjoyment of this large additional carrying power, and we have not paid the high price which many of the other companies paid for it. This is probably a matter of congratulation for us, although it is not so much so for the inventors. Legal and other professional advice upon special matters amounted to £318. The extension of the offices and quarters at St. Vincent, and the providing of tanks for the storage of spare cable having been completed, there is a reduction of expenditure on those heads in this half-year of £5,713. Other increases and decreases of smaller moment being giving effect to, the result is, as above stated, an increase in expenditure of £16,044, mostly due to the unusual number of repairs of cable falling upon us in the June half-year. In the present half-year, now more than half expired, we have so far, fortunately, had no expenditure for repairs. Therefore, having made these ample repairs, we are now in a position, I hope, to go for a period without incurring any further expense. Notwithstanding all this outlay, however, in the past half-year, we are paying you the same dividend, although we are not adding to the reserve fund in the same degree that we have hitherto done. Probably, with the large sum we have now got in reserve, it is not so necessary to make these additions, but I would mention to you that if we are to hold our own, if we are to look forward to the continuance of the prosperity which has so far been enjoyed by the Company, you must not grudge, but rather encourage, the increase of our reserve fund. I think that, after all, the reserve fund is the backbone of our system. There is an old saying that "You cannot have your cake and eat it too," but by having a reserve fund the value of your property is immensely added to, and the security of your dividend is greatly strengthened. I would, therefore, giving you my view of the matter, say that the reserve fund is one of the greatest and strongest factors which you can have in the submarine telegraph system. There are several things affecting your interests floating in the air just now. We have still in existence a revolution in Rio, and we have had something very nearly akin to it in the Argentine. It is, however, a very curious and very important factor for you to understand in regard to submarine telegraphy that revolutions, the disturbing effects of which throw privations on people, generally have somehow or other to find voice in the submarine telegraphs, and the consequence is that if times are very good, submarine telegraphy more or less benefits, while if times are very bad we do not benefit to the same extent, though we do not die out. Submarine telegraphs are used in times of hardship and privation, just the same as they are used in good and prosperous times, although, probably, not to the same extent. I hope that better times are dawning upon those countries where revolution has been so rampant lately. There is no doubt at all that it would be better for those countries if that were the case, and much more satisfacfactory for their commercial interests generally, and as we claim commerce to be our first factor, I think we may hope and wish that a more prosperous commercial state of things will soon prevail, both in the Argentine and in Brazil. In the last year or two you have had brought before you the subject of the competition that was likely to arise. In this system of telegraphs, I do not believe, as I have said on former occasions, that opposition or competition is as advantageous as many people say that competition as a rule is, for this reason—that the Submarine Telegraph Cables form a peculiar and isolated system. It is a system that requires great attention, great care, and it is a system which, more or less, dies out unless it is maintained in thorough efficiency. The amount of work that a cable can do is large, and where you put down two instruments to do the same work, of course you lessen the monetary value of the service; and what I have held, and what I hold now, in the systems over which I am more immediately presiding, is that competition is not advantageous, but we have endeavoured to show that we conduct that system on the broadest principles—principles in connection with which it must be acknowledged by everyone that, while we have the power to squeeze, we have and we exercise the power to open our hand and do generous things. That is our policy, and I think our shareholders have generally endorsed it. We have done many things with regard to our staff. They have certainly benefited by the progress and prosperity of this system, and we have laid down a scheme which some of the wisest statesmen have endeavoured to lay down, namely, to provide for our people in their later years. All these things we are bearing in mind. We are conducting what I freely admit to you I should like to call a monopoly, but a monopoly based on such principles that all who participate in the working of it ought to be satisfied that it is carried on on broad and generous principles. I think I have pretty well mentioned all the points that I had to bring

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before you, but there is one of some importance to which I have yet to allude. You will have observed in the papers lately that telegraphic communication has been established between Lisbon and the Azores. This Company, the Eastern Company, and the Telegraph Construction Company have all taken a part in carrying out that work. We did it for two reasons. We believe it is a system that may be eventually worked into a profitable and valuable one, and we also got a very valuable *pro quo*. We have got an extension for ten years of exclusive privileges, which are very valuable indeed, from the Portuguese Government. The Eastern Company has got the same privileges, and the advantage to us is probably more important and more valuable than I am prepared to put before you in figures. At all events, this Company will now have one-third interest in that Azores system, and they could not have spent their money in a better way to secure something like permanency for the next ten years to their system connected with the general system. That is an important advantage. The competition which we have to contend with I do not attach very serious importance to. I think that those who are dealing with that competition have realised the important fact that it does not pay, and any concern that does not pay does not live healthily, to say the least of it. I therefore think we may see important changes in that direction. In the meantime, I am quite certain they find that the reduction of rates does not add to their exchequer. I am speaking of the South American Company, which has been lately established, which has often been talked about here, and I think we have got this matter fairly in hand. We will treat it liberally, and in such a way that I hope common sense will prevail, but they will probably find that they will be better without this competition than with it. We have another competition, and that is by an American company—what is called the Galveston or Central American Company. That is competition which we of course recognise, and if it comes to a reduction of rates it can do a very great deal of harm; but the American, as a rule, does not lay down any system for the purpose of losing money by it, and as we know that their object is to get money out of it if they can, we shall take care that they only get money from it on principles that will be fair and just to us. We have a great banking. I think, united, our system is the biggest in the world, and they will find that in dealing with us there must be something like fair play and something like a *quid pro quo* to be given for anything they get. I have thought it necessary, perhaps, to say a little more to-day than I should do generally, and I think I have given you pretty full information upon all that is going on in connection with your enterprise. There is one other point I may refer to which is personal to the Board. For a great many years—over 20 years now—you have had a very successful and very good company altogether, and I do not think, from my point of view, that the gentlemen who sit on this side of the table have been unduly paid. We are going to make a little alteration in that respect which will lead to an expenditure of about £300 more upon the Board, and I may tell you—and I think it is well to tell you—that that £300 will come into my pocket principally. In other words, that will be an addition to the money you already pay to the Directors, but it will be in the form of salary to the Managing Director. He will cease to draw his fees as Director, and this additional sum that I have mentioned will be drawn from the Company's exchequer. We are not bound by the Articles of Association to put all this before the shareholders, but I am quite certain that looking to the honest services which you have had for 20 years from this Board, and looking at the large reserve fund you have accumulated, a little further consideration is due to the Directors on the part of the shareholders. I will now move—

"*That the report of the Directors and the accounts to June 30, 1893, now submitted, be approved and adopted, and that a dividend be now declared of 3s. per share, making with the interim dividends already paid, a total dividend of 6 per cent. for the year, and also a bonus of 1s. per share, making in the aggregate a distribution of 6½ per cent. in respect of the profits for the year ended June 30, 1893, the said dividend and bonus to be, respectively, free of income-tax.*"

Mr. FREDERICK YOULE: I have much pleasure in seconding the resolution.

The CHAIRMAN then invited discussion, but no shareholder rising to address the meeting, he put the resolution in the usual way, and declared it carried unanimously.

On the motion of the CHAIRMAN, seconded by Sir HENRY D. GOOCH, Bart., Mr. J. Denison Pender was re-elected to his seat at the Board, as was also Mr. Frederick Youle, on the motion of the CHAIRMAN, seconded by the Hon. W. ST. JOHN BRODRICK, M.P.

Mr. E. B. LIDDELL afterwards proposed, and Mr. GEORGE DUNCAN seconded, the following resolution:—

"*That the firms of Messrs. Deloitte, Dever, Griffiths and Co. and Messrs. Gane, Jackson and Jeffreys be, and they are, hereby elected auditors to the Company for the ensuing year at the remuneration of £50 to each firm.*"

The CHAIRMAN stated that up to the present time the accounts of the Company had been audited by individual members of the firms mentioned in the resolution, but it was now thought better that the audit should be in the hands of the firms named, which consisted of chartered accountants. He might state that a regular audit of the accounts of their Company, and of all the companies with which he was connected, was carried on monthly, apart from the special audit, and the shareholders might, therefore, be perfectly satisfied that everything was done straightforwardly and honestly.

Mr. HENRY NUDING inquired whether the investments were taken at cost price, or at their present market value.

The CHAIRMAN replied that they were taken at cost price, and that there was a very considerable margin of profit on them.

Mr. W. GRIFFITH then proposed a vote of thanks to the Chairman and Directors, and, while expressing deep regret at the death of Sir James Anderson, said he thought they were to be congratulated on the appointment of so able a successor as Sir John Pender. He afterwards referred to the strong financial position of the Company.

Mr. NUDING seconded the motion, which was unanimously adopted.

The CHAIRMAN, in reply, referred to his connection with the Company from the outset—from the day on which he met the late Emperor of Brazil in London, when a conversation ensued regarding a cable to His Majesty's country. The enterprise had been successful, and he was greatly interested one way or another in the Company, particularly as Chairman of the Globe Telegraph Trust, which was by far the largest holder of shares in the Brazilian Submarine Telegraph Company. He had at all times kept a watchful eye on the Company, with the object of assisting in protecting its interests. Although, therefore, he had addressed them that day for the first time, it had carried him back to the days when he took an active part in the inception of the Company.

The proceedings then terminated.

NEW COMPANIES, STATUTORY RETURNS, &c.

CORLETT ELECTRICAL ENGINEERING COMPANY (LIMITED).—The 1893 return of this Company shows that 620 shares, out of a nominal capital of £10,000, in shares of £10 each, have been taken up, of which 100 were issued as fully paid. Upon the remaining 520 shares a call of £7 per share has been made, resulting in the payment of £3,640.

DOMESTIC TELEPHONE COMPANY (LIMITED).—The statutory return of this Company, made up to July 28, 1893, has been filed. The nominal capital is £20,000, divided into 3,990 "A," or Ordinary, and 10 "B," or management, shares of £5 each, of which 2,662 "A" and 10 "B" shares have been subscribed for and allotted. Of these, 2,000 "A" and the "B" shares were issued as fully paid to Sir C. S. Forbes, for the sale to the Company of the following patents, viz., an improved telephone combination, No. 10,466, of 1892; an improved switchboard, No. 13,338, of 1892; an improved telephone combination, No. 18,423, of 1891; improvements in telephones, narrow double tympan, No. 9,496, of 1892; improvements in microphones, No. 13,146, of 1893; improved signalling apparatus for telephones, No. 16,877, of 1892; improvements in the arrangement of telephone circuits, and switching devices therefor, No. 20,670, of 1892; and improvements in telephones, No. 3,488, of 1893. Upon seven "A" shares the full amount has been called, and upon the remaining 655 "A" shares a call of £2 per share has been made, resulting in the payment of £315, and leaving no less than £1,030 in arrears.

ELECTRIC LIGHT REGULATING SYNDICATE (LIMITED).—The statutory return of this Company, made up to and filed on August 24, 1893, shows that out of a nominal capital of £1,000, in £1 shares, 865 have been taken up, and the full amount called and paid on 240 of them. The remaining 625 were issued as fully paid to Edward P. Davis and Adrian C. Collins, in consideration for the sale to the Company of their rights to letters patent No. 19,874, of November 4, 1892, for an invention relating to the regulation of the supply of electrical energy and other electrical apparatus.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended October 15th were £849, as against £902 for the corresponding period of last year, being an decrease of £53. The total receipts for the half-year amount to £12,111, against £11,755 in the corresponding period of 1892, being an increase of £356.

IMPERIAL CONTINENTAL GAS ASSOCIATION.—The Directors recommend a dividend of 5 per cent. for the half-year, and a bonus of 1 per cent.

MEDICAL BATTERY COMPANY (LIMITED).—The latest development of the so-called Electropathic Belt is the issue this week of a prospectus inviting subscriptions for 11,000 Six per Cent. Cumulative Preference shares in the Medical Battery Company (Limited), the capital of which Company is (the prospectus states) £200,000, £100,000 of which is (also according to the prospectus) "fully paid." Mr. C. B. Harness is President of the Company, and Dr. Robert Wallace, M.P., "has consented to serve on the Board of Directors in the interests of the Preference shareholders." It is interesting to learn from the prospectus that the business which the Company conducts is the manufacture and sale of all kinds of electrical and mechanical apparatus and instruments for medical and surgical treatment, and that the business has proved highly profitable in the past. The object of the present issue of capital is stated to be the establishment of a residential institution in London, which, it is calculated, will also prove highly remunerative. No reference is made to recent litigation or to its effect upon the business of the Company during the current year, information which might prove instructive to intending applicants for shares. There can, of course, be no connection between the results of this litigation and the necessity for further capital.

NOUVELLE SOCIETE DES TELEPHONES.—The Société Générale des Téléphones and the Menier cable establishments are to be amalgamated under the above title, with a capital of 18,600,000fr.

ST. JAMES' AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).—The electric current sold by the Company during the quarter ending September 29th last amounted to £4,820, as against £5,763 for the corresponding period of 1892.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended October 13, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,941.

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WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The Directors, after placing £3,000 to reserve, have decided to recommend the under-mentioned dividends for the six months ended June 30, 1893, viz:—6s. per share on the First and Second Preference shares, and 1s. per share on the Ordinary shares. The traffic receipts for the two weeks ending October 15th were £1,662, as compared with £2,035 for the corresponding period of last year. The June receipts, estimated at £5 016, realised £5,009.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Divi-dend.	Name.	Previous Week's Price, Oct. 11.	Price Wednesday, Oct. 18.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 18.
						£ s. d.		Highest / Lowest
			TELEGRAPHS					
£1,134,640	Stock	12/6	Anglo-American xd	49½ 50½	45 47	5 17 0	Jan. Apr., July, Oct.	.. ..
£2,932,680	Stock	25/0	Do. Preferred xd	92 94	84 86	6 7 11	" "	92½ ..
£2,932,680	Stock	5/0	Do. Deferred	9 9½	8 8½	..	.. ..	9½ ..
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer) ..	99 102	100 103	3 17 8	January and July ..	.. ..
130,000	£10	3/0	Brazilian Submarine	11⅜ 12½	12 12½	5 4 0	Mar., June, Oct., Dec.	12½ ..
£36,400	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	1 0⅛ ..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107 111	107 111	4 10 1	June and December	.. ..
$7,716,000	$100	7%	Commercial Cable Capital Stock	135 140	135 140	5 0 0	April and October..	134½ ..
16,000	10	8/0	Cuba Submarine	11 12	11 12	6 13 4	February and August	11½ ..
6,000	10	10%	Do. Preference 10 per Cent.	18 19	18 19	5 5 3	" "	.. ..
12,931	5	1/7½	Direct Spanish (£4 paid)	2⅛ 3⅛	2⅛ 3⅛	4 11 5	April and October..	.. ..
6,000	5	10%	Do. Preference 10 per Cent.	8⅛ 9½	8⅛ 9½	5 5 3	" "	.. ..
60,710	20	3/6	Direct United States xd	11⅜ 12	11⅜ 11⅝	6 0 8	Jan., Apr., July, Oct.	11⅝ ..
400,000	10	2/6	Eastern xd	15 15½	14⅞ 15⅛	4 5 11	" "	15⅛ ..
70,000	10	6%	Do. 6 per Cent. Preference xd	16 16½	16 16½	3 12 9	" "	16½ ..
£1,294,10	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	113 116	114 117	3 8 5	May and November	116 ..
£105 900	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 1 0	4 10 11	February & August	109½ ..
250,000	10	2/6	Eastern Extension xd	15½ 15½	15⅛ 15⅜	4 11 1	Jan., Apr., July, Oct.	15⅞ ..
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	112 115	112 115	3 16 2	February & August	114½ ..
£70 6 0	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	102 105	102 105	4 15 3	January and July ..	.. ..
£ 08,7 0	100	5%	Eastern & S. African 5 per Cent. Mor. Deb.,1900 ..	101 104	101 104	4 16 2	" "	.. ..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101 104	101 104	3 16 11	February & August	103⅜ ..
£200,000	£25	..	Do. 4% Mauritius Sub. Debs.	104⅞ 107⅞	104⅞ 107⅞	..	May and November	103⅜ ..
180,227	10	1/6	Globe Telegraph and Trust xd	9⅜ 9½	9⅜ 9⅝	4 13 8	Jan., Apr., July, Oct.	9⅝ ..
180,042	10	6%	Do. 6 per Cent. Preference xd	15½ 15⅝	15½ 15⅝	3 18 1	" " "	15⅞ ..
150,000	10	5/0	Great Northern	20 20½	20 20½	4 3 0	Jan., April, and July	20⅛ ..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	103 106	103 106	4 14 4	March & September	104½ ..
17.000	25	37/6	Indo-European	39 42	40 43	5 16 3	May and November	41½ ..
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	3 6 8	" "	.. ..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 108	5 11 1	March & September	.. ..
£100,000	£100	4%	Pacific European Telegh.4% Guar. Debs. "Red" 1942	101 104	101 104	3 16 11	" "	.. ..
11,802	8	4/0	Reuter's	5 6	5½ 6½	..	April and October..	6⅜ ..
3,381	£100 Cert.	*	Submarine Cables Trust 6 per Cent.	116 121	115 120	5 0 0	" "	119½ ..
15.609	10	5/0	West African Telegraph	5½ 6½	5½ 6½	7 13 10	January and July ..	.. ..
£260,930	100	5%	Do. 5 per Cent. Debentures	98 101	98 101	4 19 0	March & September	.. ..
30,000	10	2/0	West Coast of America	2 3	2 3	..	January and July ..	.. ..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	98 102	99 103	7 15 4	June and December	.. ..
88,321	10	6d.	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	..	.. ..	1⅛ ..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10 10½	10 10½	5 14 3	May and November	10⅛ ..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	.. ..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	106 109	106 109	4 11 9	June and December	.. ..
64,242	15	4/6	Western and Brazilian	6½ 7	6⅞ 7⅛	5 3 8	May and November	.. ..
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5⅝ 6⅛	5 5½	..	.. ..	.. ..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1⅛ 1⅜	1⅛ 1⅜	..	.. ..	.. ..
£178 2 0	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	104 ..
£222 700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	105 ..
$1,214.000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	115 120	115 120	5 16 8	May and November	.. ..
£ 69,0 0	£100	6%	Do 6 per Cent. Sterling Bonds	102 105	102 105	5 14 3	March & September	.. ..
			TELEPHONES.					
44,000	5	10/0	Chili Telephone (fully paid)	2 3	2 3	..	.. ..	.. ..
22,,,00	10,0	3½d.	Consolidated Telephone Const. & Maintenance ..	1/16 1/8	1/16 1/8	..	May and November	.. ..
2 0,000	£1	4/6½.	Oriental (11s. paid)	3/16 1/16	3/16 5/16	7 18 2	Yearly	.. ..
4 8 867	5	2/6	National	4⅛ 4⅜	4⅛ 4⅜	5 2 7	June and December	4⅜ 4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14 15	14 15	4 0 0	" "	14⅜ ..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	13½ 14½	13½ 14½	4 2 9	" "	.. ..
90,950	5	2/0	Do. 5% Non-Cumulative 3rd Pref.	5⅛ 5⅜	5⅛ 5⅜	4 13 0	.. ..	5⅞ ..
726 477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	112 114	112 114	3 18 11	January and July ..	113⅜ 11⅛
68,000	5	1/0	United River Plate	2 2½	2 2½	..	January and July ..	.. ..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	.. ..
			ELECTRICITY SUPPLY COMPANIES.					
40,000	£10	..	City of London Electric Lighting (fully paid)	11½ 11¾	11½ 11¾	..	..	11¾ ..
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid) ..	12⅜ 13½	12⅜ 13	..	..	13½ ..
19,000	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	..	.. ..
£150,000	£5	..	Electricity Supply Company Ordinary	..	5 5¼	..	..	.. ..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	.. ..	..	..	.. ..
8,32	£5	..	House to House Electric	..	.. ..	..	..	.. ..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	..	.. ..	..	..	.. ..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	.. ..	..	January and July ..	.. ..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4½ 4¾	4½ 4¾	..	..	.. ..
15,000	£5	5/0 '92	Do. (fully paid)	6⅛ 6⅜	6⅜ 6⅞	..	..	.. ..
111,000	5	..	London Electric Supply	⅞ 1	⅞ 1	..	..	.. ..
9 300	£10	4/0	Metropolitan Electric Supply (fully paid)	6¾ 7¼	6¾ 7¼	2 15 2	..	7⅛ 6⅞
£100,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	104 107	104 107	4 13 6	June and December	.. ..
6,452	£10	..	Notting Hill Electric	5 6	5 6	..	..	.. ..
9,930	£5	9½%	St. James' and Pall Mall	6½ 6⅝	6½ 6⅝	..	..	.. ..
20,0 6	£5	7%	Do. 7 per Cent. Preference	8 8½	8 8½	4 2 4	..	8⅝ ..
59,900	5	1/6	Westminster Electric Supply (fully paid)	5 5½	5 5½	3 3 8	..	5¼ ..
			ELECTRIC MANUFACTURING, &c., COMPANIES.					
77,978	3	2/1	Brush Electrical Engineering	2⅜ 3	2⅜ 3	6 0 0	..	3 ..
75,000	2	6%	Do. 6 per Cent. Preference	2⅛ 2⅜	2⅛ 2⅜	5 1 1	..	2⅜ ..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107 109	107 109	4 2 7	March & September	108⅝ ..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	3½ 4½	3½ 4½	..	January and July ..	.. ..
12,139	5	..	Edison and Swan United	..	..	..	..	.. ..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid) ..	.. ..	.. ..	..	..	.. ..
49,900	10	12/0	Electric Construction	1⅜ 2⅛	1⅜ 2⅛	..	..	.. ..
91.195	2	10/0	Elmore's Patent Copper Depositing	⅝ ¾	⅝ ¾	..	..	.. ..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 1⅛	1 2	..	..	.. ..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½ 22½	21½ 22½	5 11 1	February & August	22½ ..
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	101 103	101 103	4 7 5	March & September	.. ..
11,334	£10	6/4	International Okonite Ordinary	1 2	1 2	..	..	.. ..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	.. ..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/0 4/0	3/0 4/0	..	..	.. ..
78,949	5	1/9	Swan United (£3. 10s. paid)	2 2½	2 2½	13 19 8	May and November	.. ..
37,350	12	12/0	Telegraph Construction and Maintenance	31 33	31 33	5 9 1	March and July.....	33 ..
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	January and July -	.. ..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)..	.. ..	.. ..	..	..	.. ..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	.. ..
			RAILWAYS AND TRAMWAYS.					
£630,000	Stock	¾%	City and South London Railway	30 35	30 35	2 2 6	May and November	.. ..
37,500	£10	..	Liverpool Overhead Railway	5⅛ 5⅜	5⅛ 5⅜	..	..	.. ..

* Ex. 35,0 on account of current coupon.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 806.—Vol. XXXI. FRIDAY, OCTOBER 27, 1893. PRICE FOURPENCE.
Annual Subscription (U.K.), 19/6

NOTES.

Nothing has been heard about the certification of meters for some time. On August 15, 1892, a letter was sent from the Board of Trade to the County Council (*The Electrician*, Vol. XXIX., p. 435) saying that the several patterns of meters which had been submitted for approval had been carefully considered, and that though some of the patterns had many merits, and the laboratory tests had been in several particulars satisfactory, no meter had showed such perfection as to justify the conclusion that serious defects might not appear in actual working. Under these circumstances the Board of Trade invited the co-operation of the London County Council in providing for a thorough practical test. Pending this trial, which it was anticipated would occupy a period of about 12 months, no approval of any meter could be given by the Board of Trade. We have made inquiries about these tests, and understand that the County Council have been carrying them out, but have suggested a further extension of time. Their report will probably be communicated to the Board of Trade in the course of next month. A report upon the principles, construction, and results of various meters under scientific tests will probably be made by the Electrical Department to the Board of Trade, but it is not likely that this will be made public. The publication of the general results, however, would be of considerable interest, for although inventors and makers could learn by inquiry the limits of accuracy and other conditions necessary for obtaining a certificate, electrical engineers and others would like to know how far the conditions have been met.

The Paper by Mr. B. A. Dobson on the "Artificial Lighting of Workshops," which was read before the Institution of Mechanical Engineers, and of which a portion will be found in another column, calls attention to a mode of using arc lamps which has been singularly neglected. A Jaspar lamp at the Paris Electrical Exhibition in 1881 was thus used to light one of the upper rooms, with an excellent result. The lamp was inverted and fixed in a stand of flowers in the middle of the room, casting all the light on to a white ceiling. The common idea that a white surface is a poor reflector, giving back only 50 per cent. or so of the light, may, perhaps, account for the general hesitation to copy this method. It has been shown by Dr. Sumpner and others that the reflecting power of a good dead-white surface may exceed 80 per cent. A great advantage of this mode of lighting is that the light comes, not from a point, or from a comparatively small globe, but from a surface of many square feet. Such a surface cannot cast sharp shadows, or, indeed, under most circumstances, any noticeable shadow at all, where several lights are used.

The reflector for an inverted arc lamp should subtend a large solid angle to the arc. An examination of the curve of distribution of light from an arc lamp shows that but little light is emitted at angles greater than 70° with the axis of the carbons. A reflector to catch all the light falling within this limit would subtend a solid angle of $0{\cdot}684\ \pi$, or in plainer language—given the distance of the reflector above the arc, the radius of the reflector should be about three times this distance. Theoretically the solid angle alone need be considered, but practically the reflector should be as large as possible in order to avoid shadows, particularly the shadow of the arc lamp itself.

Mr. Steinmetz writes to us this week to defend the high estimates of the candle-power of search lights which have from time to time been made. We cannot agree with him. There are two ways of measuring candle-power. The ordinary way is direct and assumes that the rays of light are emitted from a point. Having adjusted a photometer at a certain distance from this point, the candle-power is directly as the square of this distance. The other way is not so common, but it must sometimes be used. The illumination of a surface upon which the light falls is measured, and the candle-power is calculated as that which would give the same illumination if emitted from a point at a certain distance. We have already pointed out in connection with a lighthouse at a London exhibition that, as measured photometrically, if the beam is strictly parallel, the candle-power would be indefinitely great, and if the beam were slightly converging, the candle-power would be more than infinite; in fact, the word candle-power ceases then to have any meaning.

But Mr. Steinmetz sins in good company. Dr. J. Hopkinson, at the South Foreland lighthouses in 1884 and 1885, made measurements which purported to give the candle-power of the lights. With due deference to such an authority we venture to suggest that what he did do, and what Mr. Steinmetz has done, is to make a photometric measurement and to take the square of the distance from the light as if it were a radiant point. In practice the beam of a search light is never truly

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parallel. It consists of a number of nearly parallel rays mixed with diverging and with converging rays. The latter cross the axis, and at a considerable distance the rays may be all considered as diverging. In certain cases a diverging beam is intentionally used. The light then proceeds as if from a point at a considerable distance behind the projector. The value of a search light may be estimated in terms of the *quantity of light* sent in a given direction in a nearly parallel beam, and not by its candle-power, which is a very different thing. The two concluding sentences of Mr. STEINMETZ's letter need the following qualification. The rays from the arc would proceed practically as from a point, diverging from it; the illumination produced by it would be inversely as the square of the distance from this point. But there is little or no such divergence with the search light, and therefore the candle-powers cannot be compared.

THERE are, as far as we know, only three classes of individuals who are more or less bound to hold an impartial position towards the question of continuous *versus* alternating currents. These are presidents of scientific societies, *ex officio*, consulting engineers, *ex professo*, and editors of technical journals, *coram publico*. But this attitude is made difficult by the weak arguments which are put forward by advocates of alternate currents and transformers. Disregarding their own strong points and the really weak ones of the continuous-current system, they bring forward all sorts of side questions and new inventions when they undertake to discuss relative advantages and economies. It is very rarely that we find an alternate-current man who can point to a satisfactory plant and district and a good balance-sheet and say, "This is all as it ought to be, and may be compared with a similar district supplied with continuous currents."

NOTWITHSTANDING high coal bills, blinking lights, and inability to run motors, alternating currents present most important advantages for certain cases, such as the lighting of the residential suburbs of a town, or for the rapid covering of a wide area in order to pick out the best customers. For the purpose of giving a fair hearing rather than for any convincing arguments that it contains, we print this week a long letter from Mr. R. N. LUCAS. He refers to an automatic switch. We have described two of these. Mr. TOMLINSON's, designed for sub-stations, was promised to save 26½ per cent. of the coal; we do not know that it has been used in practice. The other was an instrument of most formidable complexity. A diagram was submitted to us, and we gave a brief account of it some time ago, promising to look into it more closely after some practical expenditure of its working had been gained. Consumers are most unjustly charged for rental of transformers, but we do not know who was to pay for this apparatus. We regard the use of such a machine as a serious confession of weakness, a weakness in which we do not believe. After going into various figures, our correspondent assumes a 2½ per cent. fall on a low-pressure network and an 80·5 per cent. efficiency. We hope that sub-stations will be able to do better than this, even though Mr. LUCAS suggests that they have to make up 10 per cent. before they even equal it.

ACCORDING to the *Evening News'* interviewer, HARNESS is "not going to do anything until the articles are completed." We shall then see what we shall see. If someone would interview the Public Prosecutor we might get to know what he is waiting for. Perhaps for HARNESS to run away. It is satisfactory, from this point of view, that he is still with us; and that the Public Prosecutor has a chance of doing his duty. Meantime the *Pall Mall* continues its revelations, supplying materials for a score of indictments, if Sir A. K. STEPHENSON is thinking of doing anything. For the financial aspect of this business we commend our readers to last week's *Statist*.

Cable Interruptions and Repairs.—There are again no interruptions or repairs to record.

Kingston-upon-Thames.—The opening of the supply station, which was announced for last Saturday, has been postponed until November 4th.

Personal.—Mr. H. C. Marillier has resigned the editorship of *Lightning*. We understand that he is already well into harness in general journalistic work.

Municipal Electric Lighting.—A special meeting of the Kensington Vestry was held at 9 o'clock on Wednesday night last to consider the following resolution: "That the Vestry apply to the Board of Trade for a Provisional Order authorising the Vestry to supply electricity within the district over which it exercises jurisdiction."

Lamp-holders.—Our attention has been called by Mr. C. Scott Snell to his letter in our issue of April 18, 1885, in which he pointed out that he designed the arrangement of cross-wire loops for lamp-holders in 1882, whilst with Messrs. Woodhouse and Rawson, by whom he believes it was patented and who have made it from that day to this.

Electric Launches for Venice.—There seems to be some prospect of the appearance of electric launches on the canals of Venice. The Electric Launch and Navigation Company, which supplied the electric launches at the Chicago Exhibition, has, it is reported, disposed of a number of its launches to a company, which will put them in service on the Venice canals after the close of the Exhibition.

Clockwork Bells.—The mania for inventing strange things to go by springs, and "to be periodically wound up," has now spread to door bells, in the shape of a plausible imitation of the electric bell. You press a button, and a gong rings just inside the door as long as the button is pressed. For people who prefer that their visitors should hear the bell rather than their servants, this ought to be very useful.

Electric Lighting at Blackpool.—The plant at the new station comprises a 200 H.P. engine driving a 100-kilowatt alternator, two 100 H.P. engines driving two 50-kilowatt alternators, and three 60 H.P. engines driving three arc-lighting dynamos, and is capable of supplying current to 6,250 16 c.p. incandescent and 165 arc lamps. The contractors were Messrs. Hammond and Co., who have supplied their usual class of plant

The Geneva Water-Power Plant.—From the report of the Geneva Water-Power Supply Company it appears that over six millions of cubic metres of water have been distributed during the last year, under pressure obtained by pumping the Rhone water to a height, at a cost of 0·26d. per cubic metre. The water was supplied at a price of 0·35d. per cubic metre. Among the industries supplied in this manner is the electric generating station, which takes about 1,000 H.P.

The Electric Staff System.—Yesterday the working of the electric staff system was commenced on the Severn Valley Line of the Great Western Railway at Bridgnorth. For some time the line has been worked by the ordinary staff system, but the new working by what is known as the electric staff is by order of the Board of Trade. The electric system was tried in connection with a special train, which travelled several times between Hartlebury Junction and Buildwas Junction, and the result gave general satisfaction.

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Testing Institution.—The first electrical testing establishment in Scandinavia has been opened at Stockholm, by Herr Azel Estelle, a well-known Swedish electrical engineer. The establishment is modelled on the Physikalischtechnische Reichsanstalt, in Berlin, and undertakes the testing of electrical apparatus by instruments supplied by the institution named, the drafting of plans for electrical installations and estimates, &c.

Royal Victoria Hall.—The following are the arrangements for science lectures at the above hall during November:—November 7th, Mr. Francis Bond, F.G.S., on "Norway and the Norwegians," with lantern illustrations; November 14th, Prof. H. G. Seeley, F.R.S., on "Skulls," with lantern illustrations; November 21st, Mr. James Swinburne, on "The Mechanics of Street Toys," with experiments and lantern illustrations; November 28th, Mr. Douglas Carnegie, on "The Philosopher's Stone, or the Royal Road to Health and Wealth."

Cornell University.—This American University, which is well known to our readers from the fact that it has developed an important section in technical education, has just been celebrating what one of our American contemporaries calls its "quadri-centennial anniversary," which is to say that it has been established over a quarter of a century. During that time, and under the direction of such men as Profs. Anthony, Ryan, and Nichols, this university has done a considerable amount of useful work in technical education and research.

British Awards at Chicago.—The following awards to British exhibitors at the Chicago Exhibition are announced:—British Government Postal Telegraph Department—(1) modern telegraph apparatus in operation, and (2) historical telegraph apparatus; Corporation of Birmingham, original Woolwich dynamo; General Electric Company (Limited), London, H. I. switches and other incandescent lamp fittings; and Mr. James White, Glasgow, electro-magnetic balances; London and North-Western Railway Company, London, application of electricity to boiler-shop tools, and electric train-staff and ticket apparatus.

Remarkable Decision in Telegraph Law.—The Supreme Court of Georgia held, in the recent case of Willingham *v.* Western Union Telegraph Company, that where a telegraphic message, delivered on Sunday for transmission, did not show on its face that it related to a subject matter which would render transmission and delivery a work of necessity or charity, and where there was no averment in the declaration either that the dispatch in question did relate to such a subject matter, or that the Telegraph Company, its agent or servant, was informed that it had relation to any such matter, the failure to transmit and deliver it on Sunday was not actionable.

Exhibition Lighting.—The incandescent light plant at the Chicago Exhibition is stated to be capable of keeping 180,000 lamps of 16 c.p. alight at once, if required, "which would be equivalent," says the *Engineering Magazine*, "to the consumption of more than 1,000,000 cubic feet of gas per hour." This calculation, says the *Journal of Gas Lighting*, is correct enough, so far as it goes. What is required to be added to it, however, is the observation that no gas engineer yet born would make an equivalent plant, unless he was reasonably assured of getting more profit out of the job than the Chicago Exhibition authorities are likely to realise from any part of their enterprise, electric lighting included.

Another First Inventor.—It seems, says the *Gas World* that the inventor of the lightning conductor was not Benjamin Franklin, but an Austrian, or rather a Bohemian monk, of the name of Prokop Dyivicz. He put up a lightning conductor, and very soon afterwards the building was struck. The building was saved; but the lightning conductor was apparently thought to be something uncanny, for he was ordered to take it down at once. After this he fell back into obscurity, though before that his researches had attracted a great deal of attention; and he died in 1765. The American papers have been discussing this matter; and regret has been expressed in America that there was no bust of Divis, as he is called there, to put up at the Chicago Exhibition.

Tri-phase Motor in America.—The first system of public supply in the United States for the practical, commercial use of the three-phase current for general distribution of power, light, and heat has been made at Concord (N.H.), where a plant of this character has been erected. The first motor was started on September 29th in an engineer's machine shop. This plant has been erected for the Concord Land and Water Power Company, which is developing the water power at Sewall's Falls, in the Merrimac. The three-phase generator and motor now in operation were made by the General Electric Company at its works at Lynn, and were erected by E. F. Carpenter, superintendent of the water-power company. The Company hopes to put in several hundred small motors to be operated from this station. It is intended to use the three-phase system for almost the entire transmission of light, heat, and power.

Fast Telegraphing in Boston.—A remarkable record in telegraphic annals, both for speed and accuracy, was made, says the *Electrical Engineer* of New York, at the main office of the Postal Telegraph Company in Boston recently. Assistant-manager Bagley sent 58 messages in the unprecedented time of 30 minutes. The messages were those of ordinary character, such as occur in the regular daily transmission of business, and averaged 10 words in the body, exclusive of the address and signature. This would be faster average time than that made by Gibson, the champion fast sender at the tournament held in New York last autumn, when that operator sent 97 messages in an hour. In the latest trial the address was abbreviated, but the body of the message was spelled out in full. It will be seen that at this rate of speed Mr. Bagley was sending at a rate that would dispose of 116 messages in an hour.

The International Tramways Institution.—At the meeting of this Society, held at Budapest on September 7th, 8th, and 9th, much interest was aroused by a long discussion on the question of electric tramways, which arose on a Paper read by Herr Schmidt on the subject, and which resulted in the almost unanimous adoption of a resolution to the effect that in view of the successful introduction of electrically-driven tramways, on both overhead and underground systems, on the Continent, on which greater speed is attained and greater traffic is obtained than on horse lines, the Institution recommends, in the public interest, electric traction to both public authorities and tramway companies, and advises the former to encourage companies having concessions to adopt electric traction by means of suitable grants of facilities. The members spent two days in examination of the very successful Budapest electric tramways system.

The New Caledonia Cable.—Sir Thomas M'Ilwraith, the retiring Premier of Queensland replying to the regret expressed by the Marquis of Ripon, the Secretary of State for the Colonies, at the action of Queensland and New South Wales in committing themselves to the laying of a cable to New Caledonia, which, its promoters claim, will serve as the first section of a trans-Pacific cable connecting Australia and Canada, remarks that the complacent policy of Great Britain has allowed foreign Powers to acquire territory in the Pacific to the injury of the future Australia, and he especially instances the establishment of a French convict settlement in New Caledonia. Sir Thomas goes on to contend that the construction of the cable between Queensland and New Caledonia will mitigate evils which already exist, and declares that if the protest of Australian statesmen had been promptly heeded in the past much inconvenience and injury would have been prevented. Queensland, he said, always favoured the construction of a purely British cable across the Pacific, and would warmly welcome the support of the mother country to such a scheme.

Long-Distance Telephones in America.—The last connection was made, says the *Western Electrician*, of Chicago, on the long-distance telephone line between Spokane, Portland, and Willamette points and Tacoma, Seattle and Puget Sound points, on October 2nd, thus completing the second longest telephone line in the world, involving an outlay of nearly $250,000. The route of the line is from Spokane to Garfield, thence down the Palouse River to Colfax, and from there across the country, *viâ* Almota, Pomeroy, Dayton, and Walla Walla, to the Columbia River at Wallula, then down the Columbia River along the line of the Union Pacific Railway to Portland, from which point one branch leads south into the Willamette Valley, and the other north *viâ* Vancouver to Olympia, Seattle,

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Tacoma, and Puget Sound points. The main line is over 750 miles in length. The line between New York and Chicago, the longest in the world, covers 950 miles. Between Spokane and Portland there are but three stations permanently on the main line, viz., Colfax, Walla Walla, and The Dalles; but switches can be made at any of these points, and connection given to any of the surrounding towns.

Switzerland.—Some interesting developments of electric transmission of power and electric traction are now taking place in Switzerland, where the abundance of water-power enables electricity to compete with success with every other mode of power transmission. The Compagnie de l'Industrie Electrique, of Geneva, is now actively engaged in building eight electric cars, each fitted with 20-H.P. single-reduction motors, for the new line from Champel to Petit Sacconnex, which will pass through the centre of Geneva and will be about 5½ kilometres in length. This line is to be worked on the trolly system, the construction of which is being undertaken by the before-named Company. At Dijon it is expected to have four or five different lines of electric tramways running by next summer, and the equipment of 20 cars, of the same pattern as for the Champel-Sacconnex line, is being carried out by the Geneva electric company. As regards the utilisation of water-power, a scheme is under consideration for transmitting 3,000 H.P., taken from the Isère, half to Valence sur Rhone and half to Romans. The available fall is very low, and vertical turbines making 25 revolutions per minute are to be erected.

Electric Power Plant at Boxholm.—The electric power plant at Boxholm is approaching its completion. The works erected in 1886 having proved inadequate, says *Engineering*, and there often being a want of water, it was decided to go in for a new electric power transmission plant, coupled with a light station, and for that purpose to utilise the lowest of the waterfalls, which had not been used for several years. The fall is not perpendicular, but has an extension of about 500ft. In order to use the full height of the fall, it became necessary to build a canal along the stream, proceeding from the foot of the fall to the dam in front of the buildings, and the depth of which corresponds with the depth of water at the bottom of the fall. In this manner a fall of 20ft. was obtained, whilst it would otherwise not have been more than about half. In order to keep the water of the river apart from that in the canal, a wall about 420ft. long had to be built. The water is conveyed to five turbines, each of 50 H.P. The turbines and transmissions are on the ground-floor, whilst the dynamos, &c., are placed on the first-floor. Two dynamos, each of 225 amperes and 110 volts, supply the light, and another dynamo of 60 amperes and 220 volts supplies the requisite current to the electric railway. There will be in addition to these two good-sized alternate-current dynamos, besides a smaller similar dynamo for transmission of power to the works.

A New Method of Motor Suspension.—Among the improvements which the introduction by the General Electric Company of the United States of the new "G. E. 800" street car motor has brought into tramway practice is a new method of suspending the motor on the axle and the truck, whereby it is made to rest upon a resilient system, the weight being supported at a point immediately below the centre of gravity of the motor itself. This system of suspension is known as the cradle suspension. Immediately below the armature bearings are trunnions on each side of the motor, set in side bars which are pivoted at the front to a special casting, and supported at the rear end from link bars bolted to the truck frame. The front special casting is mounted upon six springs, two of which offer resistance to pressure upwards, and four resistance to the downward pressure. It will thus be seen that this modification is of significance in electric railway practice. The motor being set upon a spring-like cushion, the greater part of the dead weight is taken off the axle itself and is more evenly distributed to the axle bearings, and that part of the truck which can better stand the strain. This, in conjunction with the lightness of the motor, means economy of track maintenance and a decrease in the possibility of accident to the axles.

The Action of Electricity on Microbes.—The methods employed by M. D'Arsonval to determine the action of electricity on living matter have already been noticed in these columns. The process consists essentially in passing a current through a solenoid, in the interior of which the substance to be experimented on is placed. MM. D'Arsonval and Charrin, according to the *Lancet*, recently made some investigations as to the effects produced on microbes by the current, selecting for this purpose the bacillus pyocyaneus. A culture of this organism was placed in the solenoid. At the commencement of the experiment a tube of nutrient agar-agar was inoculated with two drops of the culture. After the lapse of ten, twenty, and sixty minutes respectively, further cultures were made on different tubes, which were all placed in an incubator for some hours. An examination of the tubes then showed that a luxuriant culture of the bacillus had grown in each; the forms of the colonies had undergone no change and were similar to those grown in central tubes; the pathological characteristics appeared also to be the same. The colour of the cultures, however, had been to some extent affected; for whilst in the first two tubes the organisms exhibited an intensely green colour, which was scarcely less vivid in the second than in the first tube, the colour in the third and fourth tubes was much less marked. These experiments seemed to show, then, that the electric current had some effect upon the organisms, although the action was not very marked. Further investigations in the same direction would be valuable and might possibly throw some light on the electrical state of the atmosphere as affecting the course of certain epidemics.

Madras Electric Tramways.—The Madras Tramways Company have taken possession of the freehold belonging to the Wesleyan Mission, Rundall's-road, Egmore, and commenced work, a number of workmen having been set to clear the site, dig foundations, &c. The successful tenderers for the erection of the car-sheds, offices, workshops, engine and boiler-rooms and power station are Messrs. T. Jones and Dumphy. The works will now, the *Madras Times* understands, be carried on with dispatch, and the prospects of the city having at last an electric tramway now seem near realisation. The car-sheds are being constructed to hold at present 30 cars, and admit of extension to accommodate 20 more. The connections with them will be made with the main line on the Poonamallee Road, and the lines in the sheds will be intersected with examination pits to allow workmen to get at the motors attached to the axles of the cars. The roof over these sheds, as well as that over the engine and boiler-rooms, will be pent with iron and wooden trusses and covered with Mangalore tiles. The workshop will be on the latest and most improved pattern, and well equipped, and the shafting will be driven by an electric motor supplied from the main dynamos. The engine-room will hold quadruple sets of Tangye's compound coupled non-condensing engine of 180 nominal horse-power each. These will drive a quadruple battery of Elwell-Parker dynamos, the output of each of which will be 500 volts 240 amperes—120 kilowatts; also two smaller dynamos, by the same makers, to develop 135 volts. The switchboard will have two double-pole cut-out switches, main switch and two shunt resistance switches with the necessary resistance coils, two ammeters of 300 amperes carrying capacity, two old meters and four-way switches, also circuit switches for lightning and conductor circuits. The boiler-room will be equipped with a battery of six Babcock and Wilcox boilers, each for 4,500lb. of evaporation, F. W. Berryman's heater, donkey-pumps, filters, and overhead watertanks. The whole of the premises will be lighted throughout with electricity, and a special feature will be that the men working in the shed at night will have hand-lanterns which can be attached to the main conductor and bring light to bear on the immediate spot required. The stores will be a rectangular building on the east side of the property, and in connection with the workshop. They will be terraced, and an upper story, to be utilised as storekeeper's office, will rise from over the courtyard in the centre. The whole structure, when completed, will form one of the interesting features of Madras. The first instalment of machinery has arrived by s.s. "Muttra," and Mr. Chalk, the Managing Director of the Company, is expected.

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LAMP-HOLDERS.

(Concluded from page 674.)

The General Electric Company make two distinct kinds of holder. One called **Z** pattern has a bridge of china between the two terminals; this is prolonged round the terminals in the shape of a **Z**, thus carrying out the condition of the General Electric Company's "H.I." system of interposing a china bridge between metallic pieces carrying the current. It avoids any danger of short-circuiting inside the terminal due to stray

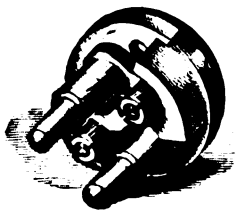

FIG. 16.—General Electric Company's **Z** pattern Base.

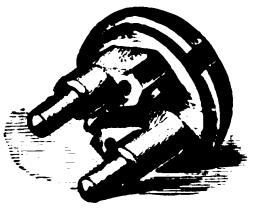

FIG. 17.—General Electric Company's A pattern Base.

strands of the flexible conductor. This terminal is shown in Fig. 16. The terminals of this lamp-holder consist of short screwed pins provided with one or more washers, and a long nut nicked at the end like a screw, and adapted for use with an ordinary bradawl screwdriver.

Their other kind, called the A pattern (shown in Fig. 17), allows the wires to pass straight through from the back, and holds them in that position by a side screw fixed in a block

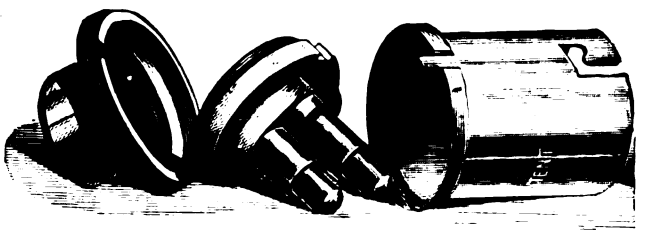

FIG. 18.—General Electric Company's Lamp-holder.

of metal, as in the "Ediswan" No. 14. The **Z** pattern is supposed to present the advantage that the wires must be bent in order that they may be twisted round the screw pins, and thus afford a considerable resistance, sufficient to take the weight of a pendant or shade. In the A pattern the wires need not be bent, and it is clear that the side screw cannot be always relied upon to withstand any longitudinal pull. It is unwise to rely upon the terminals in any case to take this

FIG. 19.—General Electric Company's Holder No. 3002, with Shade Carrier.

pull; a good cord grip should always be used for pendants or holders that are wired with flexible cord. With the A pattern it seems impossible for any loose strands to cause a short circuit with anything like careful work, for the wires need not project beyond the metal block. The A pattern of the General Electric Company presents some advantage over the "Ediswan" No. 14 in the position of the set screws, which are so arranged that rather more clearance is given between the heads of the screws and the outer barrel. Lamp-holders of this kind are often provided with a shade-carrying ring, as shown in Fig. 19.

The **Z** pattern presents an advantage over the A pattern and over the "Ediswan" No. 14 holder, when, owing to the arrangement of the fitting, a screwdriver cannot be used at right angles to the axis. However confined the situation, a small screwdriver can always be used to wire the holder.

Messrs. Burbey, Williamson and Joseph make, under licence, a lamp-holder almost identical with the "Ediswan" No. 14, the only difference being in the internal construction of the spring contacts, and in the use of "petramite," a highly insulating kind of porcelain, which is not liable to shrink in firing, and which can, therefore, be moulded with great accuracy.

FIG. 20.—Statter and Co.'s Lamp-holder.

Messrs. Statter and Co. make a lamp-holder (Fig. 20) closely resembling the standard pattern, but provided with a steel "grub" screw to fasten the holder firmly to the nipple, to prevent unscrewing of the holder when the shade-carrier is slacked back. When the holder is thus accidentally twisted, the wires may be pressed together, and if they have been skinned back too far a short circuit may take place.

Messrs. Poole and White make a lamp-holder, the base of which is glazed porcelain, and has a bridge separating the terminals as shown in Fig. 21. Messrs. Poole and White claim to be the originators of the system of dividing the metallic parts of a fitting by means of an insulating bridge.

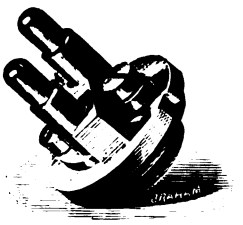

FIG. 21.—Poole and White's Lamp-holder Base.

FIG. 22.—General Electric Company's Lamp-holder, with shade-carrier and back-plate, No. 3018.

Messrs. J. H. Holmes and Co., of Newcastle, manufacture lamp-holders under licence, but confine themselves to the "Ediswan" pattern.

The Walsall Electrical Company make a holder (Fig. 23) which differs considerably from the modification of the "Ediswan" pattern in the mode of securing the wires. The buffer barrels are provided with saw cuts or slots near the bottom, and are attached to the china base by screws from the back of the base. In wiring, these screws are slacked, the wires are passed through holes in the base, and are inserted in the slots. On tightening the screws the barrels are drawn up to the base, clamping the wires firmly, and offering no liability to short-circuit from loose ends.

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Messrs. Evered and Co. make a lamp-holder which was fully described in *The Electrician*, Vol. XXIX., p. 623.

We do not propose to describe switch-holders, because the demand is so small that the design has not yet received much attention, and most switch-holders leave something to be desired. There is no separate master patent for switch-holders, since Edison's 578, of 1880, in the fourteenth claim, speaks of "a circuit-controling device for controling the circuit to one of the contact plates." The switches hitherto proposed are of three kinds, one with a handle to be turned about a quarter turn, as in most switches; a push switch with a button on either side of the holder; and a modification of the tumbler switch. The ordinary turn switch, unless provided with a weak spring and feeble contact, cannot be worked with one hand; but the two other patterns allow this. The switch must be arranged above the shade, as a rule. The chief use of switch-holders is in public buildings and offices, where many pendants are used, and where the lights have to be separately controlled. In the large sorting halls of the General Post Office, for example, separate switches for each lamp would have entailed a very large expenditure on extra wiring. But few, if any, switch-holders of the two latter kinds have been made of porcelain; the working parts are generally mounted on vulcanised fibre or ebonite.

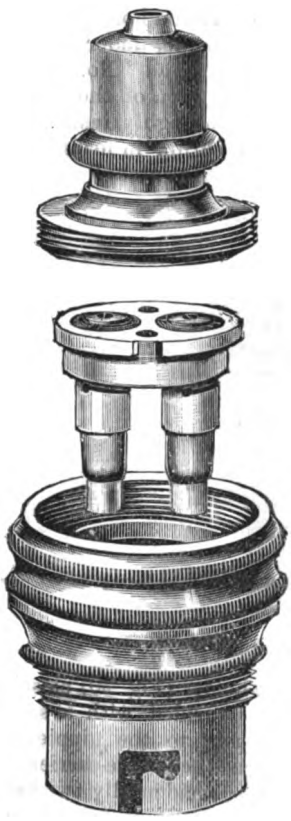

Fig. 23.
The Walsall Electrical Company's No. 93 Lamp-holder.

Lamp-holders are supported in three ways, by screwing to the nipple of a bracket or fitting, by a back-plate, or by suspension from a pair of wires. There is nothing to be said about the first method, except to commend Messrs. Statter's device for preventing the unscrewing of the holder, and the use of ⅛in. thread, instead of ⅜in. for most cases, thus allowing the ordinary insulated wires to be led right up to the terminals of the holder. A holder with a back-plate for screwing direct to a ceiling block, is shown in Fig. 22. For the lighting of cellars and larders, where there is but little room to spare, these fittings are useful, as well as in bath-rooms, where the whisk of a towel may carry away a lamp fixed to a bracket or pendant.

Fig. 24.—Belsize Holder, with Bridge.

Fig. 25.—General Electric Company's Lamp-holder, with cord-grip, No. 3,003.

Cord grips should always be used for pendants. Knotting the wires in ceiling roses is a clumsy expedient, and is occasionally done in lamp-holders. The bridge system, as shown in Fig. 24, has been employed. It will withstand a good pull, but it takes up some room, and has only been used in rather large holders, with screwed china caps. The common cord grip, which we believe is not patented, is shown in Fig. 25, and consists of a split wooden, or ebonite, plug, with a coned end and holes for the wires. The plug is held by a coned brass cap, which compresses the halves of the plug on the wires. A similar arrangement is used for ceiling roses and wall plugs, in which soft rubber can be used with advantage instead of wood.

The modern lamp-holders which we have described all fall under the Dornfeld patent. As this does not expire until January 28, 1898, there seems to be room for the manufacture of a simple lamp-holder clear of this patent. This, of course, could not be done until the Edison master-patent expires in February of next year. Considering the stress that Dornfeld put on the use of springs, it would seem that rigid pins and a spring bayonet would not be a mechanical equivalent. Nor is any spring really wanted; the lamp caps are always flat, and could be held tight against solid contacts by a screw clamp. The alternate heating and cooling of the holder would have to be provided for.

We have in conclusion to express our thanks to the Edison and Swan United Company and to their various licencees for the loan of the blocks used to illustrate these articles, and in particular, to Mr. G. Binswanger, of the General Electric Company, for information about the patents.

Erratum.—On p. 638, in the first of these articles, for A. Swan's patent No. 5,153, read 5,158.

PRIMARY BATTERIES IN THEORY AND PRACTICE.*

BY W. R. COOPER, M.A.

PART II.

(Continued from page 677.)

The number of primary batteries is so great, and the possible variations so numerous, that only a few of the chief points of interest can be touched upon in a Paper of this description. Before, however, proceeding to the various commercial forms, it may be well to consider the effect of changing the depolariser in a double fluid cell.

Mr. Sprague has conducted some experiments, in which the same quantity of each depolariser was successively employed in a porous pot, containing the carbon plate. The zinc and sulphuric acid were placed in the outer vessel. The cell was connected up through a galvanometer and a copper voltameter, the resistance remaining constant, and was allowed to run until the current fell to a certain small value. In this manner, equal quantities of nitric acid, sodium bichromate, potassium bichromate, and chromic acid were tested; the results being graphically shown in the curves that are reproduced in Fig. 11. It will be noticed that a much greater quantity of electricity was obtained by using HNO_3 than by any of the other substances. The very great difference between sodium bichromate and potassium bichromate is much greater than might have been expected, and indicates that the sodium salt is very much to be preferred in bichromate cells to the salt of potassium, which is more generally used. The actual ampere hours are given as follows:—

Nitric acid	16·0	ampere	hours
Chromic acid	6·4	„	„
Sodium bichromate.....	5·0	„	„
Potassium bichromate...	1·7	„	„

* Paper read at a Students' Meeting of the Institution of Electrical Engineers, May 19th.

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Since the internal resistance may have been considerably different in the four cases, these results do not appear to be altogether comparable.

A classification of cells may be made in a variety of ways. Perhaps the simplest is that of wet and dry cells; but some of the dry cells are very decidedly wet, so that the distinction is a somewhat superficial one. Cells may also be classed according to the number of electrolytes employed; or, again, according to the nature of the electrolyte which may be acid, neutral, or alkaline. This last method is perhaps to be preferred, though only applicable to wet cells.

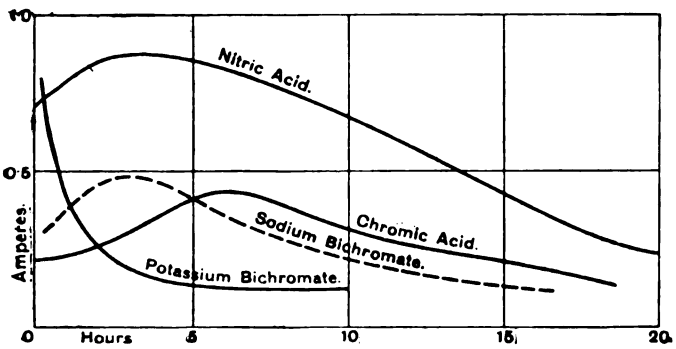

FIG. 11.—Curves showing Relative Work of Depolarisers.

Acid Cells.

All batteries employing an acid electrolyte possess certain disadvantages. There is always a tendency to local action, which increases as the cell is used, until the zinc is reamalgamated. A porous pot is generally necessary owing to the use of a fluid depolariser, and this increases the internal resistance, thereby diminishing the efficiency. Also for ordinary use, an acid is objectionable as it corrodes the contacts and fittings, and is destructive generally.

Neutral Cells.

Of those cells employing a neutral electrolyte, the most prominent are the various modifications of the Leclanché cell introduced in 1868. This cell is so well known that a description of it is almost superfluous. It consists essentially of a rod of carbon packed into a porous pot with gas carbon and peroxide of manganese, which forms the depolariser. The whole is placed in an outer vessel with ammonium chloride and the zinc rod. Such a cell is simple, but it has a variety of disadvantages. It polarises rapidly, but partially recovers by rest. The porous pot necessarily increases the internal resistance. Also the electrolyte evaporates if the cell is used for long, or is placed in a warm position; and the zinc rod is eaten away at the surface of the liquid, instead of in a uniform manner, so that the lower part of it drops off before the whole of the zinc is consumed.

A variety of forms has been devised to overcome these defects. M. Leclanché has introduced an agglomerate of carbon and manganese peroxide, in place of the ordinary mixture that is employed. In order that the depolarising action should not be limited to the surface, it is necessary that the agglomerate should be very porous. This is effected in a simple manner by adding a small quantity of sulphur to the carbon and manganese. The mixture is then pressed into the required forms, and baked, when the sulphur volatilises off, leaving an agglomerate that is exceedingly porous. This can be bound on either side of a carbon plate, thus doing away with the necessity of a porous pot, and reducing the internal resistance to as low a value as 0·25 ohm.

But the most recent form of Leclanché cell is that known as the Leclanché-Barbier cylindrical agglomerate, the composition of which differs somewhat from that of the agglomerate blocks just described. These cylinders are composed chiefly of peroxide of manganese and plumbago, which, being a good conductor, takes the place of the carbon collecting plate, this being entirely dispensed with. The zinc rod is placed in the centre of the cylinder, and is supported by a disc of paraffined wood, thus reversing the usual arrangement of the elements. The cylinder itself does not touch the bottom of the containing vessel, but is supported by a ring of metal, which is cast round the top, and rests upon a rubber seating, at the same time serving as the positive terminal. In this way practically no evaporation can take place, although any gas that is formed may escape. The cell may be left for long periods without attention; it is readily taken apart, and creeping of the salt is entirely absent. The internal resistance is 0·4 ohm. When subjected to the Post Office test of being closed through 10 ohms resistance until the current falls to half the initial value, it shows a very good discharge curve, running continuously for 17 days before this state is reached, whereas the old porous pot form reaches the same condition in six days (*see* Fig. 12).

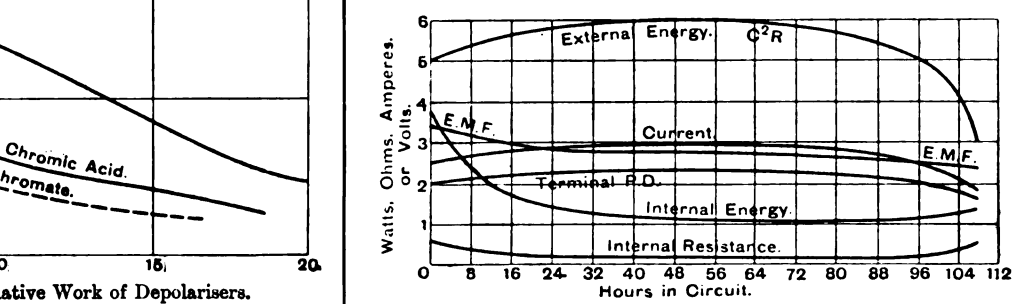

FIG. 13.—Curves of Edison-Lalande Battery. (Four Cells in Series.)

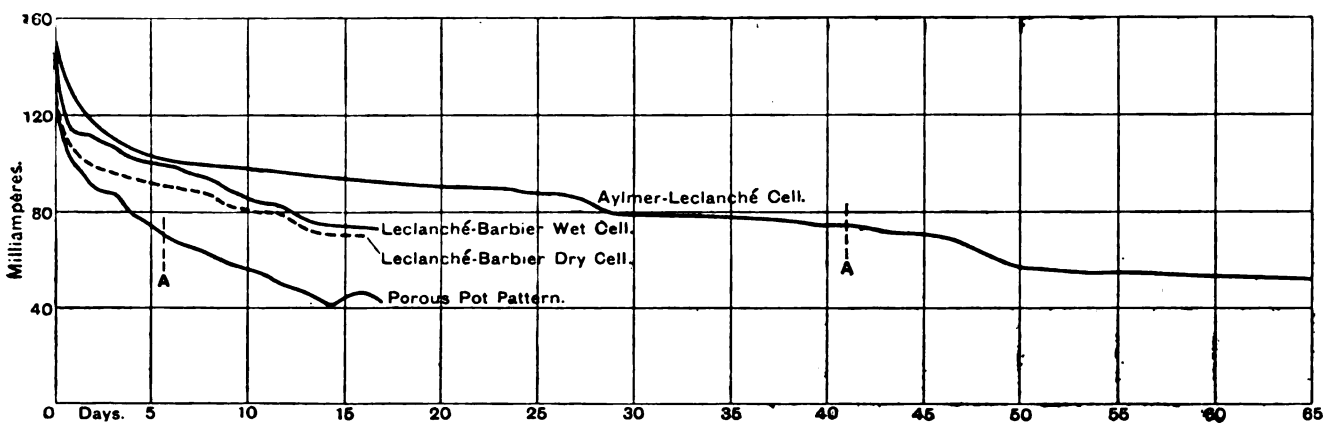

FIG. 12.—Comparative Curves of Discharge of Leclanché Cells, closed through 10 ohms Resistance. Half Initial Value of Current Reached at Points A.

Ammonium chloride, however, cannot be employed with the last kind of agglomerate described, as it destroys the porosity. To overcome this objection M. Leclanché has introduced a special exciting salt, the exact nature of which is maintained a secret. This salt has the very considerable advantage that it acts uniformly upon the zinc rod, so that the latter is almost completely consumed before replacement is necessary.

By surrounding agglomerate blocks with the zinc plate, as in the Aylmer-Leclanché cell, as low an internal resistance as 0·2 ohm is obtained. This arrangement appears to largely increase

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the output, which amounts to 90 ampere-hours when the cell is placed in circuit with 10 ohms resistance, the current only falling to half its initial value after a continuous run of 41 days, as seen by the curve of discharge in Fig. 12.

The curves of discharge which are shown, though not strictly comparable, are interesting as illustrating the advances which can be made by modifications of one form of cell.

Before leaving the subject of Leclanché cells it may be well to add a few words as to the electrolyte. Considerable annoyance is caused by creeping of the salt if means are not taken in order to prevent it. Two methods are in general use. In this country the upper part of the pot, as also the ends of the Zn and carbon rods are coated with black ozokerite. The only objection to this is that it is liable to chip off from the zinc, and thus to afford no protection after a little time if subjected to rough usage. On this account it is found better to employ paraffin wax, the zinc being left sufficiently long in the melted wax to assume practically the same superficial temperature.

In place of ammonium chloride, common salt is sometimes used. This is cheaper; but it is found to be exhausted in a shorter time than the ammonium salt, which is to be preferred on this account.

A new exciting salt, known by the name of Electrogen, has been brought to my notice as being very suitable, and appears to give satisfaction on the Continent. Upon applying to the agents, Messrs. R. W. Greef and Co., they kindly forwarded me a sample and full particulars, except the composition of the salt, which is maintained a secret. It is claimed that, by its use, 85 per cent. of the zinc is rendered serviceable; whereas only 40 per cent. is available when ammonium chloride is employed, owing to incrustation on the zinc, which is difficult to remove, and results in only partial exposure and unequal wearing of the plate. This does not occur in the case of Electrogen, and the zinc is easily cleaned. Also the E.M.F. is higher, and the electrolytic resistance constant. It also appears that, although the cost of this salt is greater, the cost of maintenance is really less, a smaller quantity being required than in the case of ammonium chloride in the proportion of 60 per cent.

Alkaline Cells.

The cells of this class, like those of the previous one, are generally of the one-fluid type, making use of a solid depolariser, and employing a solution of caustic potash or soda.

One of the most successful cells of this kind is that known as the Edison-Lalande. The elements are zinc, caustic potash, and black copper oxide, which, at the same time, serves as a depolariser and as the negative plate. When the cell is in action, a double salt of zinc and potassium is formed, hydrogen is liberated, and the copper oxide is reduced. The copper plates are blocks of the compressed oxide, which has been ground to a fine powder. The zinc plates are placed on either side of the blocks of oxide, thus reducing the internal resistance as low as 0·025 of an ohm in the 300 ampere-hour cell. They are made up to as high a capacity as 900 ampere hours. Unfortunately the E.M.F. is low, being only 0·75 volt, and the expense is rather heavy. But it is a convenient form of cell, and the deterioration upon standing idle for twelve months is said to be only one-half per cent. The discharge curve of a 300 ampere-hour cell is very constant, as shown by the diagram (*see* Fig. 13).

Dry Cells.

What is generally known as the "dry pile" has been familiar from the very beginning of galvanic electricity. Volta constructed one of zinc and copper plates with wet cloth. Zamboni made use of discs of paper covered on one side with tin and on the other with black oxide of manganese. Such piles cannot give anything but the feeblest current, for very little chemical action can take place, and this is essential to the production of current. Hence no dry cell can be really dry if useful work is to be obtained from it: as soon as it becomes dry it also becomes useless.

On account of their great convenience, a large number of attempts have been made to produce a really serviceable dry cell. Minotto used sand and $CuSO_4$; Wolf, Keiser, and Schmidt tried sawdust and cellulose; Desruelles filled a Leclanché with asbestos fibre and spun glass; and Pollak made use of a gelatine glycerine. The first one that was really successful was the Gassner cell, which appeared in 1888. This cell consists of a zinc-containing vessel, which forms the positive element, and contains the negative element, which is a mass of carbon. The remaining space is filled up with a jelly, consisting of zinc oxide, ammonium chloride, sulphate of lime, chloride of zinc, and water. It was found to compare favourably with the Leclanché cell of that date, and caused some surprise by the discovery that it might be charged, like a secondary cell, when exhausted—a property which appears to belong generally to dry cells.

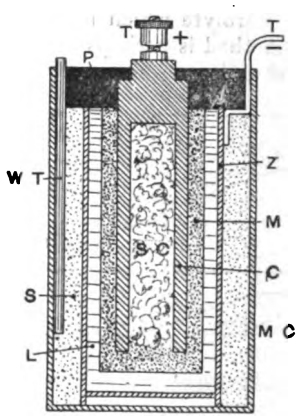

FIG. 14.—Hellesen Cell. Vertical Diagonal Cross-Section.

T T, Terminals; C, Carbon (Bored Hollow); S C, Silicate Cotton; M, Manganese Dioxide, &c.; L, Lime and Sal-Ammoniac, &c.; Z, Zinc containing Vessel; S, Sawdust Packing; P, Pitch (Top Covering); M C, Millboard Case; W T, Waste Tube.

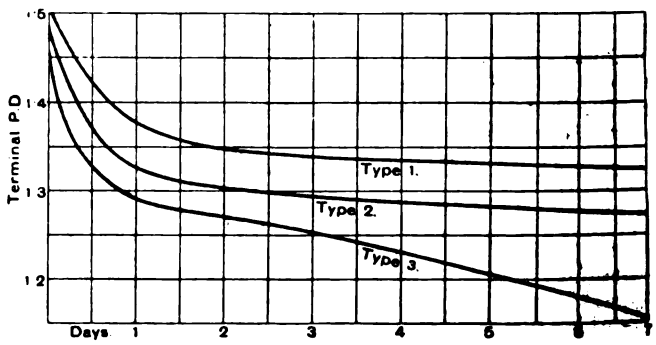

FIG. 15.—Discharge Curves of Hellesen Dry Cells, closed through 50 ohms.

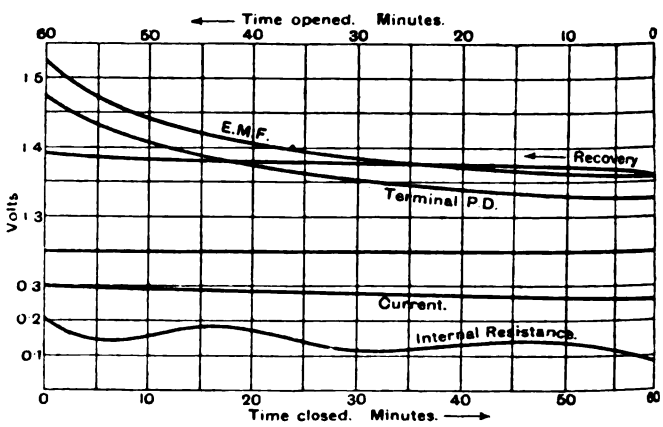

FIG. 16.—Curves of Hellesen Dry Cell, closed through 5 ohms, for 1 hour.

The Gassner cell, however, is not reliable. The polarisation is considerable and the curve of discharge is very acute. They are also liable to become short-circuited by leakage or dampness, and have therefore generally been superseded by other forms.

More recently the Hellesen and the E.C.C. cells have come largely into use. The Hellesen cell consists of a hollow carbon

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filled with silicate cotton, and surrounded first with a black paste, then with a white paste, and finally by a Zn containing vessel. The whole is packed with sawdust into the outer case, and the top run in with pitch (*see* Fig. 14*). The black paste appears to consist chiefly of carbon and manganese peroxide, with the oxides of silicon, magnesium, calcium, and

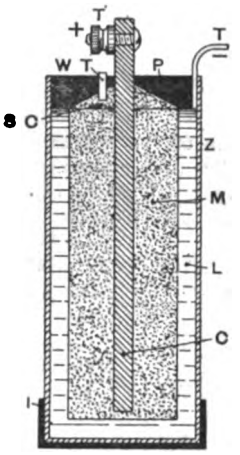

Fig. 17.—E.C.C. Cell. Vertical Cross-Section.

T T, Terminals ; C, Carbon ; S C, Cotton ; M, Manganese Dioxide, &c. ; L, Lime and Sal-Ammoniac, &c. ; Z, Zinc containing-Vessel ; P, Pitch (Top Covering) ; I, Insulating Base ; W T, Waste Tube.

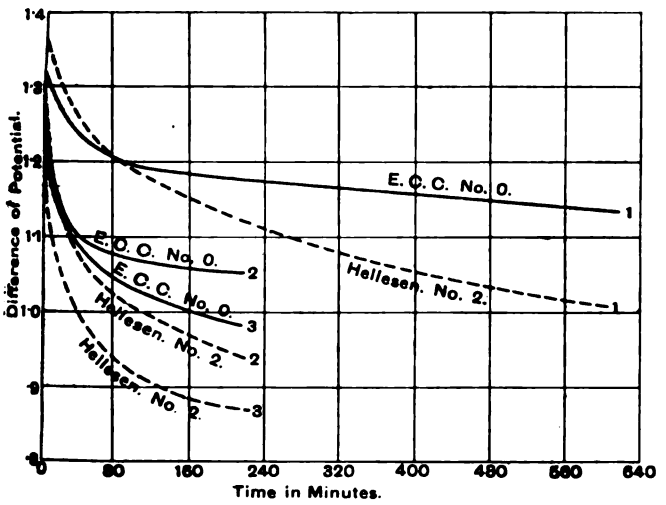

Fig. 18.— Potential Time Curves of Hellesen and E.C.C. Dry Cells. Weight of Hellesen, 2·89lbs. ; Weight of E.C.C., 3·11lbs. Current, 1st day, 0·162 ampere ; 2nd day, 0·216 ampere ; 3rd day, 0·216 ampere.

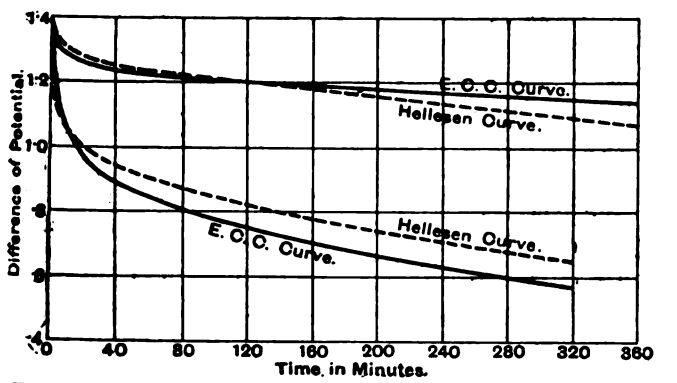

Fig. 19.—Potential Time Curves of Hellesen and E.C.C. Dry Cells. Weight of Hellesen (No. 4), 1lb. 7oz. ; Weight of E.C.C., 1lb. 1½oz. Current, 1st day, 0·108 ampere ; 2nd day, 0·218 ampere.

Iron. The white paste consists of water, lime, ammonia, and the oxides of zinc and magnesium.

This cell is capable of some very good work, as shown by the curves of discharge (Figs. 15 and 16), which are reproduced from several that have been obtained by Messrs. Siemens, but its recovery from polarisation does not appear to be very rapid.

The E.M.F. is 1·5 volts, and the internal resistance varies from 0·2 ohm in the large size to 0·5 ohm in the smallest.

The construction of the E.C.C. cell is more simple. It consists of a carbon rod in a zinc containing vessel, the rod

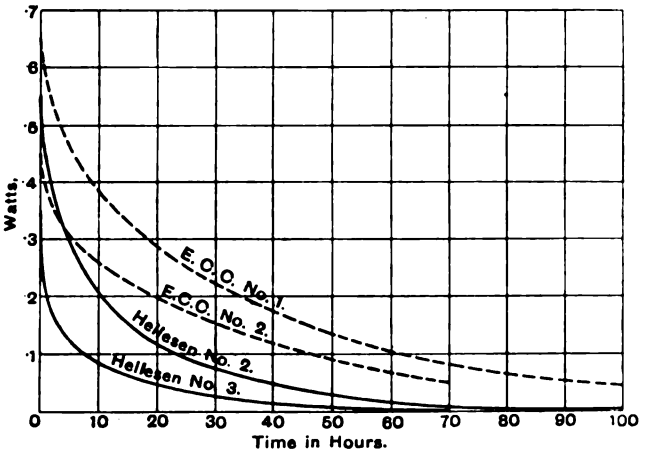

Fig. 20.—Output Curves of Hellesen and E.C.C. Dry Cells.

being surrounded first by a black, and then by a white paste. The top of the carbon is packed with silicate cotton and run in with pitch (*see* Fig. 17). The black paste consists chiefly of nearly 50 per cent. of carbon, with ammonia, water, the oxides of manganese, magnesium, calcium, and iron. The white paste consists chiefly of lime, ammonia, water, and chlorine.

Prof. Jamieson has recently carried out some comparative tests of these two cells, which appear to result somewhat in favour of the E.C.C. A few of the numerous curves of comparison are reproduced in Figs. 18, 19, and 20.

The "E. S." dry cell also appears to give satisfaction. The E.M.F. is 1·56 volts, and the internal resistance varies from 0·75 ohm to 0·20 ohm. Further particulars are not to hand.

The disadvantage of all these cells is that when once they are dry they are perfectly useless. This difficulty is overcome in the Leclanché dry cell, which is practically a Leclanché-Barbier cylindrical agglomerate, in which the exciting salt is held by some kind of cement. The top of this cell is simply closed by a disc of wood. If it becomes dry, it is only necessary to pour in some water which is absorbed, the surplus being removed, and then the cell is fit for work. It will be seen that the discharge curve falls but slightly below that of the wet cell (*see* Fig. 12). The E.M.F. is 1·5 volts, and the internal resistance in the two sizes manufactured is 0·5 and 0·6 ohm respectively.

A dry Leclanché cell is also made in which the exciting salt is held by gelatine ; this is prevented from drying by the addition of a few drops of carbolic acid.

(To be concluded.)

Electric Elevator Test.—A Frisbie electric elevator in the car-house of the Consolidated Street Railway, Worcester (Mass.), has recently been successfully tested. The trial test, says the *Electrical Engineer* of New York, consisted in raising one of the heavy cars to the upper floor. The elevator is said to be the largest electric elevator ever built in the United States. It consists of a platform 34ft. long, 15ft. high, and 10ft. wide, weighing 6¼ tons. This is guided at four points, and suspended in the centre by wire ropes, any one of which is capable of lifting a maximum weight of nine tons without danger of breaking. The steel beams which carry the sheave wheels, over which these ropes pass, weigh with their supporting columns more than four tons. The motive power for this elevator is supplied by a 20-H.P. electric motor of the Westinghouse make. This motor derives its power from the trolley circuit. The railway company will use it for lifting their cars from the ground-floor to the second story of their building whenever storage or repairs are desirable.

* Figs. 14, 17 . . . 20 are reproduced (by permission) from "Comparative Tests of Hellesen and E.C.C. Dry Battery Cells," by Prof. Jamieson, read before the Philosophical Society of Glasgow, 1893.

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Editorial, Publishing, and Printing Offices:

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ORTHODOXY IN SCIENCE.

Hard pressed for a definition of orthodoxy, a once noted exponent of it explained that by orthodoxy he meant his own "doxy" and by heterodoxy another man's "doxy"; a definition more commendable for its wit than its accuracy. It is indeed true that the way in which we hold our opinions is almost of more importance than the opinions themselves, and a good-humoured light-hearted orthodoxy of the kind thus defined, if it be within human attainment, would obviously be devoid of the disagreeable features which have hitherto marked the crystallisation in an ordered system of previously fluid beliefs or theories; a process of crystallisation which we have no reason to suppose that modern science more than any other human movement will ultimately escape.

Already some of us are inclined to resent any questioning of the correctness of our scientific fundamentals as rank heresy, and to imply that refusal to admit the logical sequence of the superstructure which has been built upon these fundamentals, proceeds from mere midsummer madness. It is not, of course, particularly conducive to the peace and quiet of a scientific mind to be called upon at frequent intervals to stand and deliver good and sufficient reasons for the scientific faith within it, but the discomfort which arises from such disturbances of our philosophical complacency is as nothing compared with the bracing effect of these cross-examinations

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by cross-grained critics and the wholesome restraint they exert upon fantastic speculation. The triumph of science one is at times tempted to think has been too complete. It has built up for itself, as it were, a walled city, seemingly impregnable; within there is indeed plenty and to spare of debating and discussing and winnowing of wheat from chaff, but from without there is no enemy to fear. The quiddling criticisms of minds from which all freshness and originality have been carefully trained away are no substitute as a restorative for the vigorous onslaughts of an acute outsider. The rough-and-ready way in which a knowledge of science was formerly for the most part acquired was no doubt destined to pass away and give place to something more systematic; but that there were compensating advantages, even the Germans themselves, to whom we defer so readily in these matters, were not slow to acknowledge. "Just because you were not passing through the usual training of the German scientist, the Academy specially counted upon you," said Du Bois-Reymond on the admission of Werner von Siemens into the Royal Academy of Science of Berlin twenty years ago; "not exactly in the sense that the unusual way in which you soared aloft is a true sign of unusual power, but because thereby, as we commend in many English physicists, your view remained fresher, your apprehension less confused, your judgment clearer, than if you, like others, had been brought up in the dogmas of the school." Yes, the passing of all minds through the same mould must inevitably lead to the turning out of minds of the same pattern, and the dead weight of orthodox authority which pressed heavily upon the mind even of a Faraday is likely to crush out all thought of independent inquiry from minds "brought up in the dogmas of the school," that is to say, taught to run in a groove, the right one it may be, but still a groove. "The respect which I entertained towards the names of Epinus, Cavendish, Poisson, and other most eminent men, all of whose theories, I believe, consider induction as an action at a distance, and in straight lines, long indisposed me to the view I have just stated"—namely, "that electrical action at a distance never occurred except through the influence of the intervening matter." So wrote Faraday in the introductory remarks to his investigations, at once ingenious and conclusive, on static induction. A properly minded man would, no doubt, have vastly preferred to have left such high matters exactly as he found them as by scientific orthodoxy established and to have earned the encomiums of his contemporaries by some elaborate action-at-a-distance straight-line mathematical investigation.

We do not suggest that there is any immediate likelihood of the establishment of a rigid "doxy" within the domain of science, but the past history of all human movements points to such a possibility, or rather probability, and signs are not altogether wanting that the tide may before long set strongly in that direction. The increased and increasing respect paid to science and scientists, the growing demand for scientific instruction, the ever widening application of science to every day problems, each by itself altogether admirable, tend in the aggregate to foster that pride of caste which in turn tends to somnolence and dependence on tradition and constituted authority rather than alertness and reliance on superiority of argument. The race of philosophers who pursue their inquiries "zealously yet cautiously, combining experiment with analogy, suspicious of their preconceived notions, paying more respect to a fact than a theory, not too hasty to generalise, and above all things, willing at every step to cross-examine their own opinions, both by reasoning and experiment," is not one that long survives after the spirit of antagonism that gave it birth has disappeared.

On the other hand, it may be very wasteful of valuable time to seek to stay the crystallising processes which result from an increasing confidence, on the part of scientists, in the premises or foundation of their constructive work. A person quite outside the region of science, one not trained in scientific thought—an enemy outside the city walls, as it were—would, in the present advanced state of science, be utterly incompetent to question the validity of its foundations. The looseness of his ideas and the jargon of his utterance would repel him from every scientific thinker. And men of science themselves are scarcely likely to institute any very rigorous direct investigation of the ultimate foundations of science. Firstly, because they would be thereby led into the intricacies of metaphysics without finality: secondly, because every fresh discovery in science, every new stone laid on the foundations, adds to their already strong conviction that those foundations are trustworthy and properly laid. The natural processes of elimination, and of survival of the fittest, which will in time weed out from science all those errors which have no legitimate basis in its foundations, must necessarily lead on towards a crystallisation of science, or the definition of an "orthodoxy." But we are comforted by the reflection that the stereotyping processes are natural, not arbitrary; they are the outcome of logical thought and not the dogmatic formulations of powerful bigots.

REVIEWS.

Minutes of Proceedings of the Institution of Civil Engineers, 1892-93. Part. IV. Edited by James Forrest, secretary. Published by the Institution.

This fourth and last volume of the *Proceedings of the Institution of Civil Engineers*, well filled as usual with communications of great interest, and numerous abstracts from foreign publications, contains one Paper which stands out from among the rest. Willans on "Steam-Engine Trials" is a sequel to the Paper on "Trials of a Non-condensing Steam Engine," read before the Institution of Civil Engineers in 1888. These two Papers together constitute the most complete series of experimental investigations that have been made on any kind of steam engine. In these Papers Mr. Willans did not in any way put forward the engine which he had designed as a peculiarly valuable one, but treated it, as Capt. Sankey observed in the discussion, merely as a piece of apparatus employed in making experiments of purely thermo-dynamical interest. Among the objects of these later trials were, to study the action of the steam in its passage through the several cylinders of compound and triple expansion engines; to observe the effects of speed, pressure, and temperature on initial condensation, and on economy generally; to fix the best ratio of expansion with any given steam pressure; to ascertain the ratio of the theoretical mean pressure to the pressure observed—called by the author the plant efficiency; to ascertain the ratio of the work done by each pound of steam to the work due from it—the thermal efficiency; to determine the pressures beyond which it is desirable to use a compound or triple-expansion engine; to determine the most economical method under various conditions of reducing the power of an engine; and to consider the advantages of jacketting. The Paper, of which the brief official abstract has been already printed in these columns, plunges at once into the "ideal efficiency" and the use of Mr. Macfarlane Gray's $\theta\phi$ diagram, which does not seem to have found its way yet into text books, and for a description of which a Paper read before the Institution of Mechanical Engineers in Paris in 1889 must be consulted. It is shown that owing to the cutting off of the toe of the indicator diagram, a much larger fraction must be

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lost by incomplete expansion in a condensing than in a non-condensing engine. The difference between the practical and the ideal temperatures in the former case is 60deg. while in the latter it is only 14deg. Diagrams are given showing the limit to the number of expansions in a very clear manner. It is shown that with 150lb. pressure (absolute) the limit theoretically is 17 expansions, but very little is gained after 12 or 13; in the last third of the length of the cylinder only 3 per cent is gained. One of the most interesting parts of the Paper to a student of thermo-dynamics is the localisation of the losses on the θ ϕ diagram. This part is by no means easy to follow, and might perhaps have been divested of some of its difficulties had the author lived to prepare the Paper for presentation to the Institution. The last section deals with the important question of the economical value of automatic expansion gear as a means of reducing the power of an engine.

Automatic expansion gears are so often recommended for electric light work that this matter deserves the attention of electrical engineers. It has been ungenerously suggested by some, who neither knew Willans nor perhaps much about steam engines, that he disparaged these gears because they could not readily be applied to his engine. It is only necessary to shout loudly enough at some persons to effectually convince them, and it is perhaps thus that the reputation of the Corliss engine was made.

"The economical value of automatic expansion-gear is usually much exaggerated, and the merits of Corliss valve-gear and of other methods of varying the power by changing the ratio of expansion, have been extolled until it has almost become to be believed that the control of the cut-off by the governor has some occult effect on economy, even when the load does not vary." When a comparison was made between a throttled engine hardly expanding at all, and using low-pressure steam and an engine doing its ordinary load with a three-fold or four-fold expansion, automatic cut-off showed marked economy. "As pressures increased, and engines were compounded, the ratio of expansion necessitated by the use of two or three cylinders, approached more and more closely to that (sooner or later reached in all engines) beyond which there is no improvement in economy. hence the economical value of automatic expansion necessarily became less and less." The author found that "in the case of an engine working comparatively non-expansively at full load, like the simple engine, the gain by cutting off earlier in order to reduce the load is great. In the compound engine, on the other hand, the gain rapidly decreases as the ratio of expansion at full load increases; whilst in the triple engine the economical value of automatic expansion gear is almost inappreciable. The question apparently turns on the question of the load at which the normal work is done. On an electric railway using compound engines necessarily working under a fluctuating load, it is probably desirable to use automatic expansion gear, because, by that means, engines arranged to work at an economical ratio of expansion at their normal load, may be made to give off momentarily much greater power at a slightly increased cost. In central electric-lighting stations it should be the aim of the engineer to so arrange the size of his generating units that the engines at work may be at all times, as far as possible, fully loaded. Under these conditions, any slight gain, when the power is reduced due to the action of automatic expansion gear, is not of vital importance, seeing that it is the gain due to one only among a number of engines, especially as the gain seems almost to disappear when high-pressures and triple-expansion engines can be used together."

In opening the discussion, Mr. Mark H. Robinson said that up to a certain point the practical man might ignore the present Paper and others like it, but if he aspired to design economical steam engines he might derive more good from the study of, say, Mr. Macfarlane Gray's diagram than from many portfolios of working drawings.

The danger which, as many thought, now threatened English engineering lay in the more thorough education and the superior mathematical knowledge of so many foreign engineers. When there was a break-down to set right in a hurry, or a day's emergency work to be done in an hour, then might he find himself in the hands of an Englishman, but he dared not shut his eyes to the progress of scientific engineering abroad. Essentially a practical engineer, the author began his work with a distinct prejudice against theory, and against the mathematical treatment of the steam engine, but he ended by becoming one of the leading exponents of the scientific treatment of the subject, simply because, as a true engineer, he could not but recognise its necessity.

Mr. Robinson dwelt upon the loss occasioned by cutting off the toe of the diagram, and showed that there was no use in carrying the expansion below 6lb. (absolute) at release. He suggested that the law of total steam consumption, which is represented graphically by a straight line, should be called the "Willans law." In the course of the discussion Prof. Kennedy, adopting this expression, said that it was strange that it had been customary to plot curves per indicated horse-power hour, without taking the trouble to plot the actually observed quantity, the weight of water used per hour. Prof. Kennedy developed this law very considerably, and showed that with a refrigerating machine, which was an engine working backwards thermodynamically, the straight line law held good. He showed a large number of examples on several diagrams, one of which included tests of a Parsons turbomotor lying in a straight line within the general limits.

It might be interesting for members to know how far results in practice bore out the figures given in the trials of Willans engines. He had frequently, during eight, nine or ten consecutive hours of ordinary work in an electric lighting station, measured all the water, and noted all the power, and the points on the curve at which the work of each engine was done: and had then compared the water actually used with that which ought to have been used; and he had found that it came within about 5 per cent. a difference not more than might be expected from the feed-pumps and the general waste. For results over a whole week, where the nights came in and when also the starting and stopping was included, it was not within 5 per cent., but was more like 10 per cent., and often considerably more. There were losses between the boiler and the engine due to the leakage of valves, to open drains, to condensation in pipes, and to several other causes which he feared had not yet been explained. Taken altogether these losses were considerable, and gave a good deal of trouble.

Mr. Crompton directed attention to the accurate measurement of steam by a Willans engine as by a steam meter. This fact had been of enormous use to him in locating the losses that existed between the consumption of coal and the development of power. Over and over again it had been found that the monthly fuel account did not agree with what it should be when calculated from the estimated value of the boilers and engines as power-producers; but in every case, after due allowance had been made for ascertained losses, the Willans engine had been cleared from blame, and had given results varying not more than 2½ per cent. from the results claimed for it by the makers when they sent it out.

The interesting discussion on this important Paper was closed by Capt. Sankey, who dealt in great detail with the points raised by the speakers, and contributed a good deal of very useful information based upon results not included in the Paper.

Personal Recollections of Werner von Siemens. Translated by W. C. Coupland. (London: Asher and Co. 1893.)

In this autobiography of Werner von Siemens we find thrilling adventures on sea and land hardly to be surpassed in any book of fiction. Indeed, in the adventure with a water-spout and the occasion on which he and his horse both fell over a precipice and alighted unhurt, each on his feet, the author appears to have had a charmed life. The book is but indifferently translated, which perhaps brings into evidence the *naïveté* of style and the simplicity with which the success of his family and the value of his own work and suggestions is treated. But it is a book which must be read by almost any one with keen interest, not only from the intrinsic value of the work and observations of the writer, but because of the interest of his character. Despite some touches of melancholy in the whole life is to be noted that singular absence of regret which is so often found in the natures of great men; and this not so much from an uninterrupted flow of prosperity, but due rather to an inherent hopefulness, a sort of practical fatalism of character, and an intense enjoyment of work, and indeed of life. To be "vividly stimulated," "interested in a high degree," "plunged in my own interesting labours," are frequent and favourite expressions, and leave an almost exhilarating impression on the reader of these remarkable recollections. For the rest, the lively description of the beginnings of things which form the backbone of our present civilisation, or at any rate of our social and commercial activity, cannot fail to be as absorbingly interesting to the reader as they were to the great inventor.

Notes et Formules d'Électricité Industrielle. By Robert P. Bouquet. (Paris: Bernard et Cie.)

This is one of the handbooks which on the Continent take the place of our so-called pocket-books. It contains numerous tables and formulæ and a mass of more or less digested scraps of information, useful and otherwise, on electrical science and engineering. It is provided with a brief index and a rather long list of errata. It will no doubt be found a very useful book of reference.

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THE IMPEDANCE OF MUTUALLY INDUCTIVE CIRCUITS.

BY A. E. KENNELLY.

In an interesting Paper on "Mutual Inductance and Capacity," appearing in No. 2 of the *Physical Review*, and recently read before Section A of the Electrical Congress at Chicago, Drs. Bedell and Crehore discuss algebraically the currents flowing in two mutually inductive circuits containing inductance, resistance, and capacity. It is the object of this article to show that such circuits when conveying harmonic currents can be treated simply and conveniently by the geometrical methods of impedance.

In the *Transactions* of the American Institute of Electrical Engineers for April, 1893, Vol. X., No. 4, p. 173, it is pointed out by the present writer that the distribution of simple harmonic currents in any network of conductors possessing resistance, inductance and capacity, can be determined by the corresponding rules for continuous currents, if definite "imaginary" resistances be substituted for the condensers and self-inductances. Mutual inductances are, however, left out of consideration, and the omission may here be supplied.

If a circuit, a, is supplied by an effective alternating E.M.F. of e_a volts with sinusoidal currents, making $n = \omega 2\pi$ periods per second, and has a "non-ferric" inductance of l_a henrys, a capacity in series of c_a farads, with a total resistance of r_a ohms, the impedance J_a of the circuit may be graphically represented by two rectangular components, namely, a horizontal resistance of length r_a and a vertical "reactance" of length $\lambda_a = \omega l_a - \frac{1}{\omega c_a}$, while by Ohm's law the current in the circuit becomes $i_a = e_a/J_a$ amperes.

Now suppose a secondary circuit b, of impedance J_b, whose components are similarly r_b and λ_b, to become linked with a through the influence of a mutual inductance of μ henrys.

The first tendency will be for the current i_a in a to set up an induced E.M.F. in b of $\omega \mu i_a = e_b$ volts, which would give rise to a current in b of $i_b = e_b/J_b$ amperes. But this current when flowing would act from b as a primary on a as a secondary circuit, and set up in a an induced E.M.F. of $\omega \mu i_b$ volts, the current from which would be superposed upon i_a, and would in turn react upon the circuit b. The successive modifications in primary and secondary currents would cause them to rapidly converge towards values so adjusted that the current in each circuit obeys Ohm's law after the E.M.F. induced by its neighbour has been taken into account. Calling i_A the finally modified or resultant current strength in the primary circuit, i_A would be established by the E.M.F. e_a unaided if the primary impedance J_a were altered to J_A, such that $i_A = e_a/J_A$. This virtual impedance J_A is obtained from J_a by increasing the resistance component r_a by $n^2 r_b$, and diminishing the reactance component λ_a by $n^2 \lambda_b$, where $n = \frac{\omega \mu}{J_b}$. The primary current is thus

$$i_A = \frac{e_a}{J_A} = \frac{e_a}{\sqrt{(r_a + n^2 r_b)^2 + (\lambda_a + n^2 \lambda_b)^2}},$$

the induced secondary E.M.F.

$$e_B = \omega \mu i_A,$$

and the induced secondary current

$$i_B = \frac{e_B}{J_B} = \frac{\omega \mu i_A}{J_B} = n i_A.$$

The effect of bringing the circuit b into relation with a is to modify the impedance of the primary a, and to establish in b the E.M.F $\omega \mu i_A$.

An equivalent to this result was first given by Maxwell.

As an example of the application of this process, the case represented in Fig. 1 of a primary and secondary circuit may be considered. Condensers are inserted in each circuit for the sake of generality, but their removal may be effected when requisite by assuming that in the formula their capacity is infinitely great.

In the primary circuit a let the total resistance $r_a = r_1 + r_2 + r_3 = 20$ ohms, the capacity $c_a = 10$ microfarads $= 10^{-5}$ farad, the inductance $l_a = (l_1 + l_2) = 0{\cdot}2$ henry, the effective E.M.F. $e_a = 100$ volts.

In the secondary circuit let the resistance $r_b = 50$ ohms, the capacity $c_b = 10$ microfarads $= 10^{-5}$ farad, the inductance $l_b = 0{\cdot}05$ henry.

Let the mutual inductance be $\mu = 0{\cdot}05$ henry and the frequency $n = \omega/2\pi = 159{\cdot}15$, so that $\omega = 1{,}000$.

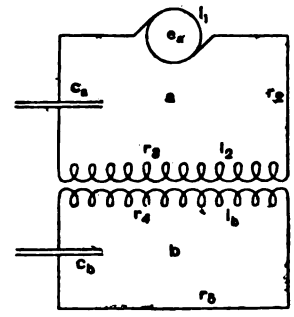

FIG. 1.

Then Fig. 2 represents the corresponding impedance diagrams for the primary and secondary circuit. O E = 20 ohms, O B is the primary inductance speed $\omega l_a = 200$, B D the capacity-speed-reciprocal $\frac{1}{\omega c_a} = 100$, laid off downwards, so that E D gives the normal impedance $J_a = 102$ ohms. Similarly S R represents the secondary impedance $J_b = 70{\cdot}7$ ohms, the reactance λ_b being here

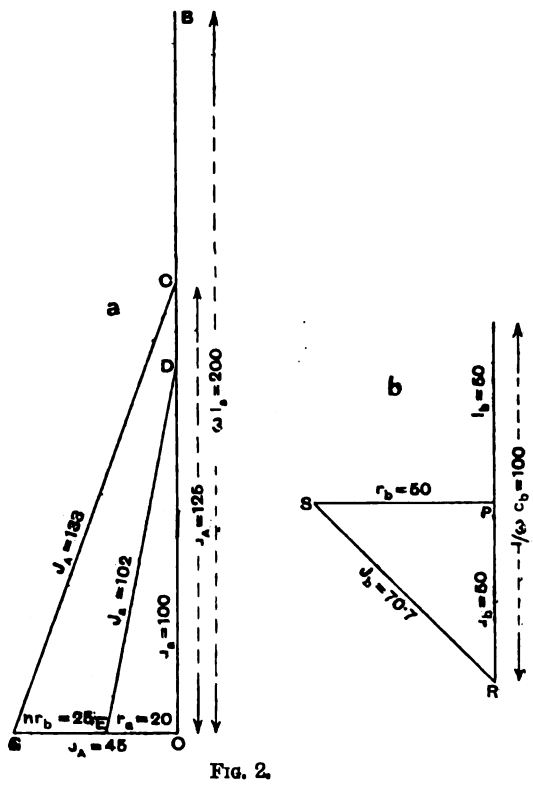

FIG. 2.

negative, by reason of the excess of capacity-speed-reciprocal over inductance-speed. The factor n^2 is now

$$\left(\frac{\omega \mu}{J_b}\right)^2 = \left(\frac{1{,}000 \times 0{\cdot}05}{70{\cdot}7}\right)^2 = 0{\cdot}5,$$

so that according to rule the primary resistance is increased by $n^2 r_b = r_b/2 = 25$ ohms to G. Half the secondary reactance is now deducted from the primary reactance, but since λ_b is negative $-n^2 \lambda_b$ is positive, and the primary virtual reactance is increased to O C = 125 ohms. G C therefore represents the virtual impedance $J_A = 133$ ohms, of the primary circuit, in which the current will be $i_A = e_a/J_A = 100/133$ 0·752 ampere, whence the secondary E.M.F. will be $\omega \mu i_A = 37{\cdot}6$ volts, and the secondary current $e_B/J_b = 37{\cdot}6/70{\cdot}7 = 0{\cdot}532$ ampere.

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To illustrate the ready application of this method to more complex cases one more example may be permitted.

Fig. 3 represents a simple harmonic E.M.F. acting upon the primary circuit of an induction coil shunted by a condenser.

The secondary circuit of the coil is closed through a resistance. In order to determine, by the ordinary algebraical process, the currents and voltages in the various branches of this system, a determinant of the sixth order would have to be solved. By the graphic methods of impedance treatment the solution is readily obtained, and a check is kept upon the arithmetical work, even if the diagrams are subordinated as mere guides to their equivalent numerical operations. The first step is to find the impedance of the secondary circuit, then to modify the impedance of the primary branch B N K G for the mutual inductive effect; next to find the joint impedance of this modified primary branch and the condenser in parallel; and finally, to sum this joint impedance with that of the main branch B D G, for the total effective impedance

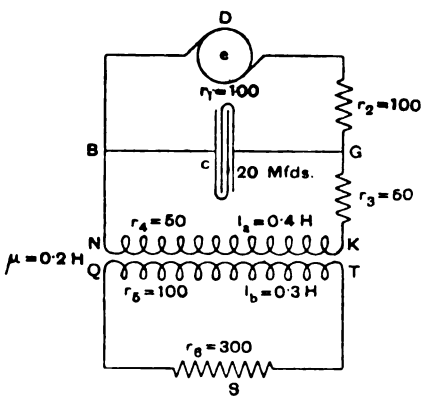

Fig. 3.

of the main circuit. This, divided into the effective E.M.F., gives the main current by Ohm's law, and the various branch current strengths immediately follow.

Let e = 1,000 volts effective, at $\omega = 1{,}000$ or $n = 159{\cdot}1$ ∽.
$r_1 + r_2 = 200$ ohms.
$r_3 + r_4 = 100$ ohms.
$r_5 + r_6 = 400$ ohms.
l_a = 0·4 henry $\therefore \omega l_a = 400$ ohms.
l_b = 0·3 henry $\therefore \omega l_b = 300$ ohms.
μ = 0·2 henry $\therefore \omega \mu = 200$ ohms.
c = 20 microfarads. $\therefore 1/\omega c = 500$ ohms.

Then diagram b of Fig. 4 represents the impedance of the secondary circuit, O P being the resistance of 400 ohms to scale, O R the reactance of 300 ohms, and P R the impedance J_b of 500 ohms. The factor of mutual influence $\left(\frac{\omega \mu}{J_b}\right)^2 = n^2 = 0{\cdot}16$ so that the increments of the primary branch components are $0{\cdot}16\ r_b = 64$ ohms, and $-0{\cdot}16\omega l_b = -48$ ohms. Diagram a shows the impedance of the primary branch B N K G, and its modification under mutual inductive effect from Y V to Z W = 388·3 ohms. Diagram g shows the vector sum Z′ R′ of the vector reciprocals of Z W and of the condenser impedance, to a conveniently altered scale, while the reciprocal of Z′ R′ is Z″ R″ in diagram h = 878·7 ohms to the original scale. This is the impedance of condenser and coil in parallel. The impedance ($r = 200$ ohms) of the branch B D G is now added vectorially in diagram h, bringing the impedance of the main circuit to A R = 1071·7 ohms.

The main current in B D G will therefore be 1000/1071·7 = 0·933 ampere. The drop in B D G will be 0·933 X 200 = 186·6 volts. The effective voltage between points B and G = 813·4 volts. This voltage acting upon the condenser impedance of 200 ohms establishes in the condenser an effective current of 813·4/200 = 4·067 amperes. The effective impedance of the modified primary coil branch B N K G is 388·3, and the current it receives 813·4/388·3 = 2·1 amperes. The E.M.F. in the secondary circuit is this current multiplied by $n = 0{\cdot}4$ or 420 volts, and the current strength in the secondary circuit is consequently 420/500 = 0·84 ampere.

A current of less than one ampere in the supply circuit thus supports a current in the primary winding of the coil of more than two amperes, with the assistance of the condenser at what may be regarded as the receiving end of the line.

By this method any network of circuits containing resistances, capacities, and self or mutual inductances under the operation of simple harmonic E.M.F.'s can be treated up to any reasonable degree of complexity with little difficulty, when the corresponding direct algebraical process would be prohibitively laborious. If the E.M.F.'s may not be regarded as sinusoidal it may be possible to analyse them into sinusoidal components, to then treat these separately

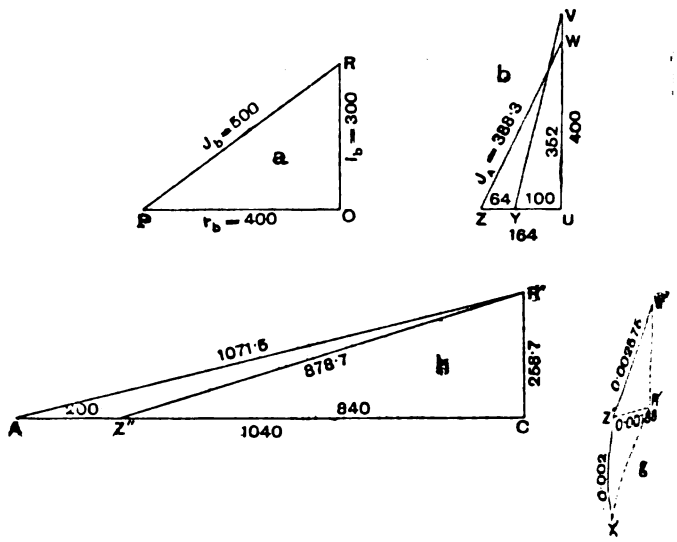

Fig. 4.

and afterwards sum their resulting currents geometrically. The phase of each current can be readily found from the impedance diagrams. Hysteresis in the induction coils and condensers is for the present ignored, which will no doubt limit to a great extent the practical application of the system; but it is at least of some advantage to possess a method which brings harmonic-current circuits almost on a par in simplicity with continuous-current circuits, and under the direct application of Ohm's law by geometrical extension, even if the secondary influences of iron have to be at present omitted or left for secondary consideration.

THE "AJAX" LIGHTNING ARRESTER.

A novel form of lightning guard for attachment to electric light and power circuits has recently been brought out by Mr. R. W. Blackwell. This is known as the "Ajax" lightning arrester, a general view of which is shown in Fig. 1. The arrester is constructed on the magazine principle, being composed of a charge of 10 or more separate fusible lightning guards, which are designed to come into operation successively. Each flash of lightning is earthed through a single guard which it fuses, and by the act of fusing the guard it causes a new guard to be placed on the circuit, ready for the succeeding lightning flash. A single fusible guard is shown in Fig. 2, and consists of a pair of fine brass wires, 2¾in. long, made to lap each other three-quarters of an inch at their near ends, with $\frac{1}{16}$th of an inch air-gap between them. A short piece of glass tube is sealed over the lapping portion of the wires, to keep them clean and dry. By connecting the outer ends of this guard the one to the line and the other to earth, a simple and cheap arrester is produced. This is accomplished by providing each fuse with two soft rubber plugs, so spaced by the knots in the wires that the rubbers will fit tightly into the porcelain cover of the arrester box (*see* Fig. 1), allowing the free ends of the wires to project through the cover into the channels of the porcelain box containing the carbon termina-

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rods; but they do not come into contact with the latter. Loose pieces of carbon, made like small wedges, connect the free ends of the upper fuse to the carbon terminals. In this position the arrester is ready to be placed in circuit.

In operation, the atmospheric discharge finds a free passage to earth, except one small gap of $\frac{1}{20}$th of an inch, which is promptly bridged. The discharge starts an arc, which short-

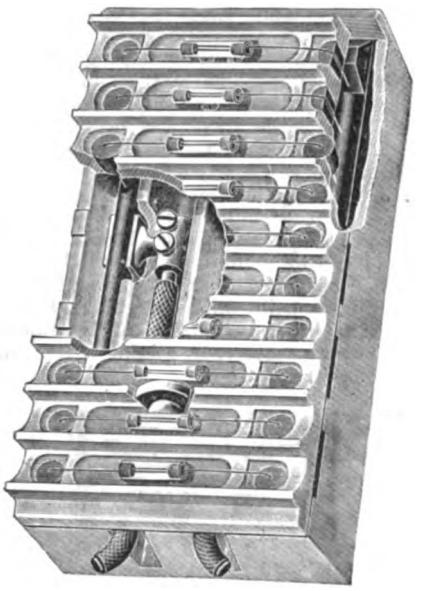

Fig. 1.

circuits the line at this point, and the sudden rush of current is sufficient to entirely consume fuse No. 1, and the carbon wedges immediately drop to the free ends of fuse No. 2, bringing it into operative position. Ten fuses are considered enough to protect any locality during a single thunderstorm, after which the arrester should be examined, and any missing fuses be replaced with new ones.

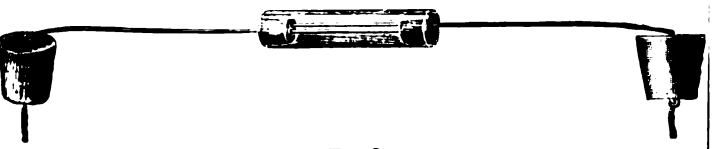

Fig. 2.

New fuses may be readily inserted by removing the cover, which, after the arrester is refilled, is replaced with the carbon wedges connecting the top fuse, as before. Since the operation of this arrester depends upon a short circuit, it is designed only for circuits using a ground return or a ground wire, and is especially adapted for tramway practice, being applicable to the pole line, cars, or power-house.

THE ARTIFICIAL LIGHTING OF WORKSHOPS.*

BY BENJAMIN A. DOBSON.

In manufacturing districts the use of artificial light is of considerably greater importance for work of all desciptions than it can be elsewhere. Whether the work be fine or coarse, delicate or bold, a better light is needed than for work which does not come under the head of manufacture. In Lancashire the staple industries of engineering, machine-making, spinning, weaving, bleaching, and dyeing, are mainly established in certain centres; and with them is invariably associated in the surrounding district the great coal industry. Although Lancashire coal has a number of excellent qualities, yet it is one that makes the most smoke of any. A large portion of the manufacturing industries, great and small, date from a number of years back, when smoke-consuming and smoke-preventing apparatus had not yet been devised; and many of the factories are working at the present day under pretty much the same conditions as when they started. Hence the atmosphere in all manufacturing towns in Lancashire is heavily charged with unconsumed carbon, producing an excess of cloud and fog, which, while inducing an excess of rain, acts also as a screen against the rays of the sun, and thus does a double injury to the neighbouring agriculturist, the producer of the country's native wealth. A circle of 30 miles radius around Manchester is said to include a larger population than an equal circle around any other place in the world; and within this circle, about 12 miles north-west of Manchester, lies Bolton, the town with which the author is best acquainted, where all winds, except the west and north-west, bring the surcharged atmosphere from other manufacturing districts, producing at any season of the year, if the wind happens to be slight, a sky ranging from dull lead to dark brown. For four years in succession it has occurred at the writer's works, that on June 21st, the longest day, the gas in every room, amounting to nearly 7,500 jets, has had to be lighted by 11 o'clock in the morning, and has remained lighted until work ceased; and this has occurred also in other towns, and in weather that ought to have secured abundant sunshine. To such an extent does gloom prevail that in clear weather the effect of bright sunlight becomes even distressing to the eye-sight, simply from the rarity of the contrast.

Requirements for a Well-lighted Workshop.—Firstly, the light, if artificial, should be sufficiently intense to give the power of clear and natural sight over any portion of the work. For enabling the work to be performed with ease the light should evidently be arranged to produce as nearly as can be the effect of natural sunlight. The light of the sun is diffused by the atmosphere; and unless its entrance is limited in extent, such shadows as it may produce are only natural shadows, so natural that the eye has no difficulty in following detail in any visible part. In this respect therefore artificial light should as far as practicable imitate the best natural conditions. Secondly, the light should be so diffused as to avoid casting shadows, or placing any one portion of the work in too great relief, as compared with the general tone of the whole. If the work were being done in front of a window which faced the sun, a certain portion of it would receive an undue amount of light, and give a false idea alike of size and distance, owing to the contrast of the overlighted and underlighted parts. This might be a natural light, but would nevertheless be improper. Thirdly, the light should be of such a character as to have no tendency to injure the sight by a blinding glare. This remark applies either to a good gas-flame or to the electric glow-lamp, from both of which the light is well diffused; the rays, being all comparatively weak, are easily diverted and thus distributed. But the effect of having either a bright gas-flame or the still brighter glowing wire before the eyes is exceedingly fatiguing and destructive to the sight, and in combination with the dust of workshops makes it a wonder that ocular diseases are not more common than they are. Fourthly, the light should be of such a character as to leave the atmosphere free from noxious emanations. Any kind of natural or electric light will fulfil this condition. The artificial light that most infringes it is gas, which varies much from town to town, and even in the same town from time to time; but it is generally so impure as to be deleterious to health and comfort in the products of its combustion, which is always more or less incomplete. Fifthly, the light should not unduly raise the temperature of the room in which it is employed. If, on a hot day, a gas burner has to be lit for every person in a crowded workshop, as has to be done in certain manufactories, the combustion of so much gas affects the temperature greatly, and thereby produces lassitude among the workpeople, together with various ailments which are almost in proportion to the amount of gas consumed. Sixthly, the light should be simple and capable of easy control. The whole arrangement should be so contrived that nothing but the simplest knowledge and experience are required for turning the light on and off. This implies, of course, both a central control and also various points of sub-central control. Seventhly, the cost should be kept within such limits as will render the light practicable at the present day for those who have to make their livelihood in their special trade in open competition with the rest of the world.

Electric Lighting by Inverted Arc-Lamps.—Some years ago, while engaged in visiting and examining certain mills on the Continent, the writer was much struck with a mode of lighting which he then saw for the first time. This consisted in the use of electric arc-lamps of from 1,600 to 2,000 c.p., suspended in a white enamelled reflector at a certain distance below the whitewashed ceiling of the mill. The first he saw was of 2,000 c.p., and thoroughly lighted a large room of about 40ft. square with light sufficient to see to pick up a pin off the floor. The walls of the room, as well as the ceiling, were whitewashed. The light had a sort of bluish tinge, and looked like bright moonlight, but with much greater illumination and entirely without shadows. This appeared so striking that he made a few experiments at once, and found that it was possible to see into the interior of the machines, and even underneath them, in a way that up to then would have seemed incredible; and

* Abstract of Paper read before the Institution of Mechanical Engineers, on Wednesday, Oct. 25, 1893.

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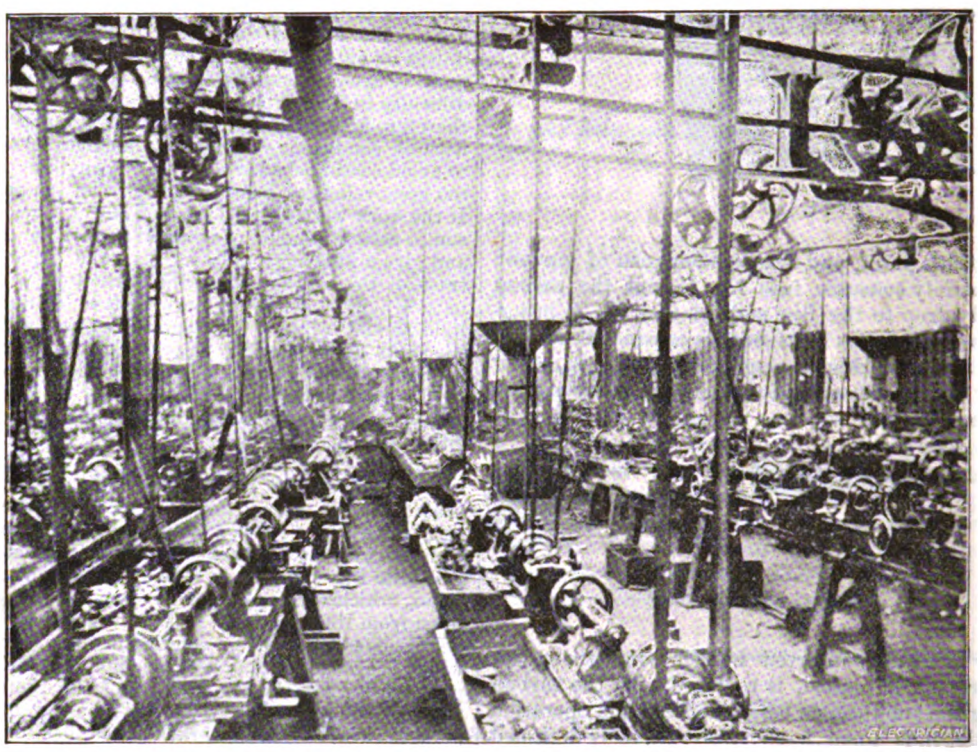
further, that it was not possible to make a shadow of any description, even when holding a hat only 2in. above the floor: all that could be seen in the centre of the covered part was a comparatively slight deepening of the shade. In other departments of the factory he found the same plan equally effective, and the diffusion of light so complete as to be astonishing.

Incandescent Glow-Lamps.—At that time the author's firm were engaged in replacing gas by incandescent glow-lamps on the Edison-Swan system in a large machining room at their own works, which is 345ft. long by 76ft. broad and only 12ft. high, containing 239 machines tended by 200 workpeople in the area of 26,220sq. ft. The exigencies of trade had required that annexes should be constructed almost all round the building, thus further diminishing the amount of natural light that could gain admission. Along the whole of the centre of the shop, for a breadth of some 50ft., gas was burning day and night; and in the close muggy weather of autumn and the fog-laden days of hot summer, the atmosphere of the room became most oppressive, in spite of the best ventilation by Blackman propellers; even at six o'clock in the morning, on entering the room, the smell was most objectionable. It was noticeable, too, that an undue proportion of the men suffered from diarrhœa, which was in fact a standard complaint, and furnished the constant explanation for absence from work. Although sometimes this was simply an excuse, there can be no doubt that the exhalations caused by the imperfect combustion of a gas not absolutely pure will suffice to explain the possibility of a large number of men being affected thereby. The incandescent glow-lamps, each with its own switch, and covered with a wire guard, were attached to the gas brackets, which for this purpose were left just as they had been. Within a week of the application of these lamps, the importance of the third requirement, with regard to glare, was amply proved; for nearly every workman had devised a shade of one kind or another, some of white or brown paper, some opaque, and some translucent. No better device than this has been found; it does not look neat, being simply a makeshift; but it answers the purpose, costs nothing, and is applied in a moment. The results of the alteration were curious; the atmosphere was improved, the heat considerably diminished, diarrhœa as a general complaint ceased, and was at first succeeded by bronchitis, which, however, was found to be of a temporary nature, and disappeared as soon as the workpeople in that room had become acclimatised.

Nevertheless with the result of this lighting the author was not satisfied. The shop was as dark and gloomy as with the previous gaslights. The number of lamps broken by accident and by carelessness was so great as to become a serious consideration, their price being out of proportion to their actual cost, and no allowance being made in regard to royalty in replacing broken lamps which had already paid royalty. The writer then made two further journeys to the Continent, in order again to examine the plan of the inverted arc-lamp; and on the first occasion returned more favourably impressed than before. The second journey was therefore made with the view of going more thoroughly into the details, and of concluding arrangements for conducting a trial of the plan in his firm's establishment. On this occasion he had the opportunity of examining a large weaving shed at Ruysbroek, near Brussels, on a dark winter night. The dynamo was driven from the main engine of the mill, and was a fine piece of work. Corridors lighted by incandescent lamps led thence to the vast weaving shed, which had the usual roof containing glass panels almost upright facing north, with a plastered ceiling sloping southwards from the top of each glazed panel, and lighted from an inverted arc-lamp in each bay between the pillars. The impression upon entering the doorway was that the large room was brilliantly lighted by the mid-day sun; no glare, no flames to be seen, but a golden light pervading the whole of the vast enclosure; the colour of the hair, complexion, and costumes of the workwomen perfectly distinct; under the looms not the slightest trace of shadow. In fact the result attained was an absolutely perfect ideal light for textile work. The bluish tinge of the arc light itself, when lighting direct, is more apparent than real, because it does not prevent the most delicate shades of colour from being appreciated. If, however, it is considered disagreeable or undesirable, it can be altered, as it was in this particular weaving factory, by mixing a trace of yellow with the ordinary whitewash; the ceiling is then still white, but the apparently bluish tinge is eliminated.



Workshop Lighted by Inverted Arcs. (From a Photograph taken at 10 p.m.)

The result of this visit was the application of four inverted arc-lamps in the large low machining room at the writer's works. Over 50 tons of castings are daily taken in and out of this room; and there must be at least 300 tons of castings of various sizes and descriptions, in progress of treatment, stacked and piled in different places on the floor; there is therefore all the more necessity for good lighting in order to avoid accidents. The darkest portion of the shop was chosen, and the four arc-lamps were placed in approximately the best positions for lighting a certain area. The ceiling not being plastered, it was considered advisable to nail up to the joists light scantlings, which were afterwards white-washed. These lights have now been running almost day and night for about two years, and with unqualified success. The four arc-lamps have replaced twenty-six glow-lamps; but whereas each glow-lamp lighted up its own work only and a few inches around, the whole of the area lighted by the four inverted arc-lamps is bathed in a gentle temperate light, absolutely equal in all parts. This was encouraging, as an arrangement of this description involves a heavy expenditure; and it was therefore considered advisable to have further experience before going more largely into it. Moreover, this plan of lighting would not always be applicable. If the ceiling were very low it would scarcely be practicable, because the arc lamp must

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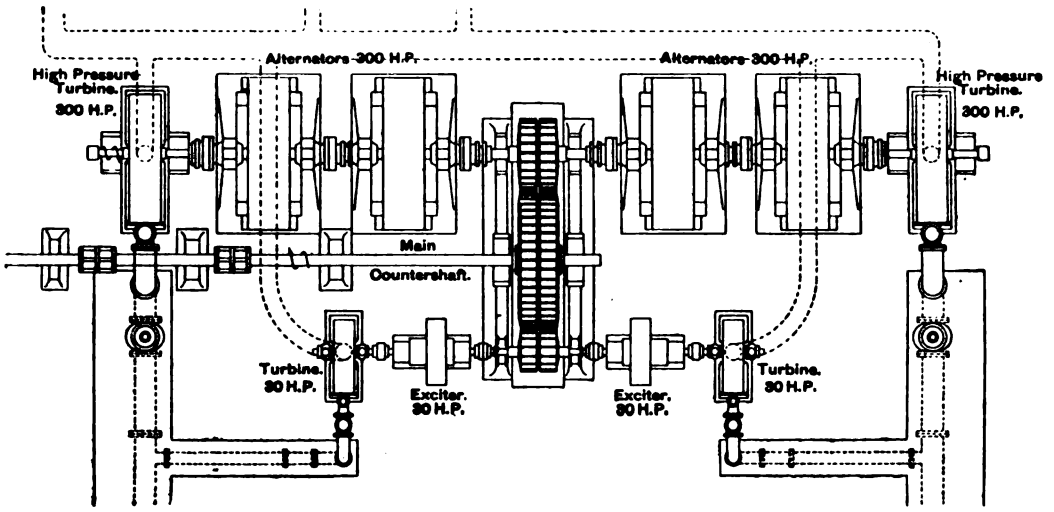
hang a certain distance below the ceiling and still leave head room. Also there are places where the amount of light required is so small that it would be injudicious to go to the expense of applying these lamps, which are capable of so much more duty. It was determined, however, to make an experiment on a practical scale at the author's works, and with this object to apply inverted arc lamps for the lighting of a three-storey building with large attic floor above, the latter being used as an iron and wood pattern-room.

THE ZÜRICH ELECTRIC SUPPLY.*

This station has been working since August, 1892, and is carried out on the alternating-current system by the Maschinenfabrik Oerlikon. The plant contains features of much interest. Power is derived from the Letten waterworks, where the falls of the River Limat are used for purposes of water supply and power transmission. The falls provide about 1,000 H.P. derived from 10 Henschel-Jonval turbines, and nearly 300 H.P. is used in pumping water for the town supply ; about 250 for a rope-transmission for industrial purposes (shortly to be abandoned), and about 400 H.P. are available for electric lighting purposes ; but since this is not enough for the 30,000 lamps for which the station is designed, the turbines are assisted when necessary by steam engines.



Plan of Electric Light Station at Zürich.

The accompanying plan shows the arrangement of the new electric light station. Under the old arrangement the ten turbines arranged two and two (as seen on the left of the figure) drove in parallel along main countershaft at 100 revolutions per minute by means of toothed gear wheels. Two new turbines (in the middle of the figure) have been added, each giving a minimum of 175 H.P., gearing like the others on to a prolongation of the main countershaft. This prolongation carries at the further end gear wheels as shown, driving on one side a countershaft at 200 revolutions, to which the alternators can be coupled by rigid couplings ; and on the other the exciters at 400 revolutions.

On either side of the gearing are two alternators and an exciter, with a high-pressure turbine of 300 H.P. and another of 30 H.P., capable of being coupled to alternators or exciters respectively. These turbines are automatically regulated by centrifugal regulators, and are also capable of hand regulation. One 300 H.P. turbine and two 30 H.P. are at present running.

Steam engines have also been added as reserve power, helping the low-pressure turbines and gearing on to the main countershaft. Three Galloway boilers (two already set, each with 1,100 sq. ft. heating surface and 120lb. pressure, feed two compound engines, one installed), making 76 revolutions and delivering 300 H.P. They are set opposite the new low-pressure turbines.

As will be seen from the plan, the dynamos can be driven either from the high-pressure turbines or from the main countershaft ; the latter, again, either from the low-pressure turbines or the engines, and either together with, or independently of, the pumps. The mechanical couplings of the dynamos are arranged so that a dynamo can be switched in in five positions corresponding to the corresponding points on the current curves of the two machines.

The electrical part of the installation comprises at present two alternators and two exciters. The former are of the well-known Kapp type, and are of 300 H.P. each. The fields are in the form of a massive casting with 30 projecting poles. The armature is of the well-known pattern. The field castings are mounted on slide rails, give easy access to fields, armatures, and to all joints and couplings. The machines give 2,000 volts and 100 amperes at 200 revolutions per minute the frequency is 50 ∿. The exciters are Manchester-type machines. They give 100 volts 200 amperes at 400 revolutions.

The switchboard is remarkably simple for so large an installation. Hand and automatic regulation is provided. The mechanical coupling of the alternators ensures their running perfectly in parallel, as a machine cannot be thrown into gear except in a position in which it is in step with those already coupled to the omnibus bars.

The system of mains is very original. From the station two main cables run direct to the distributing centre in the middle of the town. The loss of volts up to here at full load is 5 per cent., and the regulation at the station is such as to keep the pressure at this point constant. From this distributing centre direct cables without any branching lead to the transformer stations ; these distributing cables have a drop of 1 per cent. at full load. The transformer stations convert the 2,000 to 200 volts, a three-wire system of secondary distribution being used. There are seven such transformer stations at present in use, containing transformers of 20-kilowatt output each. A special set of conductors is used for the arc lighting, and six lamps in series are placed across the 200-volt mains. 9,000 lamps (8 c.p.) were use in April last.

* Abstract from the *Zeitschrift für Elektrotechnik*.

DIRECT-CURRENT DYNAMOS OF VERY HIGH POTENTIAL.*

BY F. B. CROCKER.

This treatment of the subject is in no sense a formal Paper, being merely a note of some experimental results which I have obtained from two dynamos with very high potential, and it is well, I think, to define what I mean by that expression, which is in some doubt. By very high potential I mean from 5,000 to 11,000 volts. Machines of this character have received comparatively little attention, either from scientific experimenters or practical engineers. Considering these machines historically, the first fact that meets our attention is that there exists a general and deeply-rooted idea that direct-current dynamos of very high potential are not at all practical. This unfavourable opinion is particularly strong in regard to the use of such machines for the transmission of power for any considerable distance ; in fact, such a system is considered to be almost out of the question. The actual historical and practical facts are that the high-potential direct-current machines were more extensively and successfully operated when the dynamo first came into general use about 1880 than any other type, either direct or alternate. Furthermore, their number and size have largely increased, and the voltage at which they can be practically worked has been steadily raised until we now have about 60-light arc dynamos of the standard size on large machines generating about 3,000 volts, or 10 amperes. Arc dynamos of 90-light capacity are also regularly made by several manufacturers, and 120 or even 125-light machines are built and used. I happen to know of one station where there are four arc dynamos rated at 125 lights, which run every night with a load of from 100 to 105 lights. These machines must have force to generate about 5,000

* Address before Section C, World's Electrical Congress, Chicago, August 24, 1893.

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volts each. No great practical or other difficulty is found in operating arc machines, except that of danger to persons; but this is merely due to the high potential, and does not depend very much upon the type of machine or character of current. Nevertheless, when it is suggested to use direct currents in the transmission of power, we are told that nothing over 1,000, or at the most 2,000, volts is at all practical. Why this discrepancy between the 5,000 volts, which are practically used in arc lighting, and the 1,000 or 2,000 volts that are considered the limitation of such machines for power transmission? Perhaps the first answer to this question would be to say that the current is limited; that when you have 5,000 volts you cannot have more than 10 amperes, and if you want more amperes you must have less volts; consequently the number of watts, which, of course, is the entire question in power transmission, is limited. For example, the machines which I cited, and which are in practical and successful use, are 5,000 volts E.M.F, generate only 10 amperes, and consequently have a capacity of 50 kilowatts, which is a small power, comparatively speaking, for power transmission, but is sufficient for ordinary arc-lighting circuits. That, of course, is a fairly good explanation of why such machines are not applicable to power transmission. But is there any such limit as 10 amperes to the current? I myself always look with very much suspicion and doubt upon any such arbitrary limit as that. Experience has shown me that those arbitrary limits are usually imaginary. Now, it is a fact, however, that should be added to this historical consideration of the subject, that numerous attempts have been made to employ such machines for power transmission and other purposes, and it cannot be said that those attempts have been successful; in fact, it can be said that they have been unsuccessful, but there again we have merely the negative of it. Now, when we come to the actual construction of such machines, and that is really the only substantial point that I can bring before you, I have actual results, although I cannot say that there is any particular feature of such machines which is radical or which will insure their successful operation. The first point, of course, is insulation. That must be above suspicion. The ordinary limit of one megohm of insulation is simply nothing for such machines. One megohm of insulation resistance, with a voltage of 10,000, would give 1/100 of an ampere and 100 watts; consequently the machine insulation would be rapidly heated up and destroyed; therefore, you must realise that a megohm, or even several megohms, is no insulation at all for such a machine. It should be at least 1,000 megohms, which is number one, in fact. The next point is the commutator, because, although the commutator might be considered the first point, as a matter of fact we must have the insulation before we can operate the machine at all, even for a few moments. The commutator, of course, must have a number of sections. It must have a considerable thickness of mica insulation between the bars, more than is ordinarily employed; I should say a full sixteenth of an inch. On the end of the commutator, where you get much more than the ordinary voltage between the bars, you require very much more thickness of mica insulation, or some other insulation, than is ordinarily given.

The next point is the material for brushes, and I have found in that particular feature the most peculiar and important differences. In the first place I consider that it is impossible to run an ordinary mica insulated commutator with copper brushes at that potential, the reason being that this film of copper which is worn off of the copper brushes by the mica is a sufficiently good conductor at that E.M.F. to carry many watts. At an E.M.F of, say, 500 volts, we have no such difficulty, because, even if we use common brush connections, the film of copper that is rubbed on to the surface of the mica would not carry sufficient watts to cause any trouble; but at 10,000 volts, with a total E.M.F. in the neighbourhood of 100 volts between the bars, the amount of copper, even although it is an almost infinitesimal film, is sufficient to carry, as I say, many watts. Now, I have found that with a potential of only 5,000 volts, which I have experimented with, copper brushes could not be used for half a minute; that the copper would work off on the mica and immediately produce a ring of fire all around the commutator. Naturally one would use carbon brushes in such a case, because the current is very small, comparatively speaking, and there is no reason why we should not use carbon brushes. When you come down to the carbon brushes, I have also found that the hardened carbon is better, for the reason that it does not produce a deposit or layer of carbon on the commutator to produce the same effect which the copper does, but not to the same degree, because carbon is a much poorer conductor than copper; therefore carbon brushes, with a comparatively small area of contact and a fairly good pressure, not very great, but sufficient to ensure good contact, seem to be the proper working conditions.

The machines I have actually constructed are two. One was a small machine of 1 H.P. capacity, and the armature was a fluted armature. Some persons may think that is exactly wrong, but the results do not seem to show that it was. It was very perfectly insulated with mica and wound with double silk covered wire. The potential of that machine was intended to be 5,000, and I have succeeded, by slightly raising the speed, in getting 5,500 volts out of it. It had only 32 commutator bars. That machine is not, of course, a practical machine, but it did run for hours at 5,000 volts, for an hour and a-half at 5,500 volts, and several times without any difference.

The next machine, which is a much more practical machine, was of 5 H.P. capacity, and designed to generate 10,000 volts. It did generate 10,000 volts at a little below the calculated speed, strange to say, and gave 11,000 volts at about the speed it was designed for, which was 1,800. This machine had 108 commutator bars, a much more practical number for such a voltage. The current of that machine was intended to be between three and four-tenths ampere, which gives about its capacicy. It must be remembered that these machines did not give their full capacity, owing to the fact that the wire is extremely small, and therefore the percentage of copper in the winding is small. The winding is largely made up of silk, consequently the capacity of the machine is reduced by that fact. That is inherent in any machine wound with extremely small wire. The current actually obtained from these machines is in the neighbourhood of their rated capacity. It would be unfair to myself and to you to deny the fact that there is a spark when you approach the current capacity of the machine, and I think at the current capacity the spark would be too great.

Now, as to the application of these machines, I would say that the purposes to which I have applied them have been ordinary experimental work. For example, one of these machines at 3,000 or 4,000 volts will run a Geissler tube very beautifully. It will produce any other of the so-called electrostatic effects, that is to say, effects produced by very high potential in small quantities. It will, for instance, act very much like an electrostatic machine or a friction machine. It will cause one of these electrical flyers to revolve. In other words, you can get all the electrostatic effects similar to this potential from an ordinary frictional machine.

Another purpose to which the machine is applicable is testing of insulation, and, in fact, that is one purpose for which I made it. It is a very good way to test insulation. You will immediately ask, why not use a high potential transformer as being more convenient and not having a commutator? I answer that by saying that I do not think that is the same test. If the wire is exposed to a direct-current strain, I do not think an alternating-current test is proper. If a wire is subjected to a direct-current strain, it should be subjected to a direct-current test. If it is subjected to an alternating-current strain, it should be subjected to an alternating-current test. The other application is, of course, power transmission, and that will be discussed hereafter, and I would say that, of course, it is not necessary to have the total voltage generated by one machine. In any plant no one dynamo should constitute more than a comparatively small fraction of the total plant, and if you have five dynamos in a central station or power transmission station, there is no reason why they should not be connected in series as well as in parallel, and if you want five machines, as I think you do, in order to guard against the trouble from break-downs—five to ten machines—then you can easily connect them in series and subdivide the voltage just to that extent. Each machine can generate a few thousand volts, two to five, and you could get the total voltage by the proper series connections of several machines.

THE RETURN CIRCUIT OF ELECTRIC RAILWAYS.*

BY THOS. J. McTIGHE.

The progress of the trolly system of electric railways has been so rapid as to become almost bewildering. A multitude of improvements had been added, the necessary result of careful thought and ingenuity of the electrical engineer, and the critical study of the practical railway manager and his assistants. But this has been mostly true of the track and overhead construction and the cars and power equipment. The return circuit has been rather neglected, being largely a case "out of sight out of mind." Originally installed on a basis evidencing immature study, and necessarily without experience, it has been left to shift for itself, or rely upon Mother Earth to open a frictionless path for the nearly exhausted pressure to get back to the power house. Few practical investigations of efficiency have been made, and data are meagre. Yet the return circuit is in some respects as important a factor of the system as the overhead circuit, and a moment's thought will show this to be true. The efficiency of an electric circuit depends upon the resistance of all the parts. We carefully figure out the amount and size of overhead wire so as to bring down the waste of energy in transmitting current to the motors, and we should be logically bound just as carefully to plan out the return circuit. There is this important difference, too, in our favour in the latter case, that, while we must have all copper overhead, and consequently must

* Abstract of Paper read before the Street Railway Association of the State of New York at Rochester, September 20, 1893.

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struggle with the spectre of cost, when we get in the ground we have a veritable tower of refuse present in the rails, if we but choose to take proper steps to avail ourselves of their valuable help. Track rails are necessary, and they are getting better and bigger for our circuit purposes, and I believe that it will not be long before the absurd and costly supplementary wire will have joined the vast army of discarded expedients, and with it the earth as a permanent part of the return circuit, except in some special cases.

On a wet day in moderate weather the earth is available, and to a very large extent, I believe, considering that with a 70lb. girder rail and double track we have something like 30,000 sq. ft. of earth contact per mile of track. But we cannot rely upon this doing us the same service in long spells of dry weather. Still more, we cannot rely upon it doing any good whatever in severe winter weather. It is not uncommon in this state for frost to penetrate 3ft. in the ground, and to stay there for a whole winter. Under such circumstances the earth-return must go out of our calculation. It is during severe winter that we want to realise our very last watt in the hard pulls we must contend with almost daily. We are told that the strength of a structure is measured by that of its weakest part under the most unfavourable conditions it is to meet. Similarly, in a compound electric circuit the total resistance must depend upon the condition of highest resistance to be met with in any of its component parts. We must plan so as to have our return circuit efficient in the most prolonged summer drought and in the most severe frosts of winter. Ground plates and pipes laid below permanent water level are a refuge in a few favoured localities, but the same can hardly be said of plates and pipes laid in the ground whose moisture depends upon the wayward elements. I have made a large number of calculations as to what should be the total resistance per mile of the return circuit under different methods of the construction of the circuit. In making these calculations I have eliminated the conductivity of the earth, because in average winter weather the earth turns a very cold shoulder to the track. I have eliminated the conductivity of the fishplates, because I believe that under average conditions the comparatively small areas of contact surface are too much oxidised to be of much benefit. I have eliminated all the refinements upon which exact scientific analysis of the subject would insist, such as changes of temperature, moisture, and other conditions which are more or less insignificant in the practical work. I have based the figures on the ratio of 6 to 1 in comparing the resistance of the ordinary soft steel rails with that of our usual commercial copper, and for the latter I have followed the ordinary tables adopted by the wire manufacturers. I have not discriminated between the different assignable values for resistance in the various forms of rail bonds, and have calculated only for the specific metal used in the comparisons, leaving the merits and demerits of the form out of the question. I will refer to the last later on.

In studying the general situation prior to constructing, in the spring of 1891, the railway system of Lincoln (Neb.), I investigated the subject somewhat closely. Though, at the time and under the local conditions, and advocate of iron rail bonds, I was and am yet convinced that supplementary ground wires are an unwise extravagance. I will try to give you the reasons for this belief. In steel rails we usually say that every 10lb. weight per yard means one square inch of cross-sectional area. And every square inch of such area can be brought to terms of copper by dividing by six. The resistance is easily determined, and we thus readily arrive at some important results for comparison. For example, take the average city railway rail as being a 70lb. girder. Its area is substantially 7 sq. in., and the four rails of a double track make 28 sq. in., equal to a single steel bar 4in. thick by 7in. wide. This is electrically equal to a bar of copper having 4·66 sq. in. in area, or, in other words, a copper conductor 1in. thick and almost 5in. wide. With such a magnificent path for our returning current, does it not seem absurd to supplement it with a No. 0 wire, whose area is that of a rod a little over a quarter of an inch square? But when we find the rail resistance per mile to be but 0·0086 ohm, while that of the No. 0 wire is just sixty times greater, the absurdity seems to grow, and it becomes a case of sending a very small boy to do a very big man's work, with the man standing idle on the spot.

A few roads have the supplementary doubled along both tracks, and a few have used slightly larger connected wires than No. 4 B. and S. The West End and the Brooklyn City Railroad Companies laid their tracks with double supplementary copper wires (No. 0, B. and S.), but found them totally inadequate, and now have put up many miles of huge return feeders or mains at great cost. Even these are inadequate. In Brooklyn these return mains (500,000 circular mils) are, when possible, suspended on the elevated railroad structure. I am informed that occasionally the insulation scrapes off and the return main makes contact with the iron work. Heat enough is developed at this leak to soften the insulation for many feet, thus showing that the resistance of the main return is still too high.

I am of the opinion that it would to-day well repay any company using copper supplementary wire to rebond its tracks on, because on the average it would save the cost of such change in one year. And I say the same to those using iron rail bonds.

There is still another phase to this whole question of the return circuit, to which I will briefly refer. I mean the electrolytic decomposition of the rails, when earth is relied upon as the major part of the return circuit. That there is such decomposition must be true. The soil under our paving has for many years been plentifully soaked with ammonia from animal refuse, with ordinary salt in the winters of bygone horse-car days, and to these have been added the leakage from the underground gas pipes. Certainly, such soil, when wet and in contact with the rails, presents all the requisite features of an active depositing bath, there being no dearth of cathodes below. Hence, so long as a considerable current takes place from rails to earth, there must necessarily be a good deal of direct electrolytic decomposition of the rails. Let me take an extreme case. It would scarcely be exaggeration to assume that on Tremont-street (Boston) or Fulton-street (Brooklyn) there is a massing of slowly moving cars, amounting to, say, 100 for one mile of double track. Let the rails used be 70lb. girder, and for the current I should say 20 amperes per car for 15 hours per day would be a fair average. $100 \times 20 \times 15 \times 365 = 10{,}950{,}000$ ampere hours per year. If all this went back to the generator by way of the earth the decomposition of the rails every year would be 7,665,000 grammes, or about 17,000 pounds of iron—nearly eight tons lost from the mile of double track in one year. As the mile of 70lb. rails would only aggregate 220 tons, it would not be many years, at that rate, till the rails would be qualified for a pension for loss of both feet incurred in the service, and in time we might have an illustration of the proverbial "two streaks of rust and a right of way." I have assumed an extreme case, but I have no doubt that there is a considerable amount of direct electrolysis of the rails. Nothing can be done to entirely avoid it, but it can be reduced to a minimum by overhauling the track circuit and giving it as great an electrical value as possible, and it might be retarded by dipping the rails before laying, similar to gas and water mains. In abandoning as much as possible the rather uncertain supposed advantages of the earth-return, we would to a corresponding degree rid ourselves of troubles with gas and water pipes and telephone circuits, and yet would be as safe from lightning as we are at present. If it be admitted, then, that it is desirable to obtain from the track structure as great a conducting power as possible, the question arises, How shall it be done? This at once brings us to the subject of rail bonds, and a criticism of the various types used, with a view of arriving at the best from all points of view. There have not been many types brought out by the manufacturers. Probably the earliest was made of a piece of wire having its ends coiled around two rivets and dipped in solder. This form is still much used, but it is objectionable. By its use four contacts exist at every rail joint, *i.e.*, rail to rivet, rivet to wire, wire to rivet, and rivet to rail. To ensure its position in the rail the rivet must be upset, and this, in a great number of cases, either starts or completely loosens the contact between the rivet and wire. If it escapes this, the constant vibration of the rail, sooner or later, causes loosening of the wire on the rivet. Once looseness occurs, the bond is of little use. Again, the essential nature of such a rail bond precludes the use of any large wire in its construction. Still, many roads have used them, and are still doing so. The wire generally used is No. 4 B. and S., sometimes iron and sometimes copper. Another type which has met with much favour consists of two soft-iron pins with enlarged heads, which are drilled transversely to receive the connecting wire which is upset after passing through the heads. This form is open to the same objections as the previous one, being in three pieces, the integrity of whose contact is almost sure, sooner or later, to be destroyed, whether the intermediate wire is iron or copper. Later on appeared the ingenious and, from a purely constructive aspect, very economical, "channel pin." It met an enormous sale, and it is to-day in extensive use. It requires three pieces, is not capable of riveting in the rail, and its form prevents the pin and wire from completely filling the hole in the rail, and rapid corrosion of contact is inevitable. Being merely driven wedge-like into the rail-hole its stay is not reliable, and by corrosion and continual vibration it becomes loose and almost valueless. There is, too, a tendency for the workman to force the wire against the sharp edge of the hole while driving the pin, thus weakening the wire very materially. It, too, like the rivet-and-wire bond, has a limitation as to the size of the connecting wire. No matter how carefully the mechanics of the job are attended to, we have a mere plug driven in a hole. Another type of rail bond is that composed of a piece of copper wire with cast copper rivets electrically welded thereto on projecting stems the size of the wire. This is an attempt in the right direction, but does not work out in practice. The electric weld is apparently uncertain, the union in many cases under my inspection being so imperfect that it could be broken by hand. The small copper castings exhibit radial crystallisation, making welding difficult. Many also break in applying to the rails, and such happenings destroy confidence.

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I now come to what is known as the "solid one-piece bond," which has sprung into great favour. It would be disingenuous were I not to announce that this rail bond is a patented invention of my own, but I hope that you will admit that I am trying to view this question from a disinterested standpoint.

This solid, one-piece rail bond is simplicity itself. It is merely a wire with expansion curves at its ends on each of which a heavy shoulder is swaged from the wire itself, so that both the rivet ends thus formed and the intermediate wire are all one solid integral piece. From rivet to rivet there can be no failure of contact, except by forcible rupture or total corrosion, and there can be no failure of contact between bond and rail, because when the rivet end is properly headed up, the connection made is perfectly water-tight and air-tight, and is proof against pounding and vibration. There is no solder required, no parts to shake loose, and there is no restriction in size of wire, as the bond can be made of No. 4 wire, and it can be made of No. 0000, and larger if desired. I suppose the great majority of rail bonds used span around the fishplates, which nowadays are quite long. My belief is that this is a mistake. The 12in. bond has the advantage in the total track resistance of from 40 per cent. to 50 per cent. A 12in. solid bond, with its expansion curves, makes a distance between rivet centres of about 8in. Electrically considered, it does not matter what part of the rail end is used for bonding. The holes can be drilled through the flat "tram or through the floor of the rail, 4in. from the end, just as readily as through the web or stem. There is no difficulty whatever, and I can imagine no type of track construction forbidding the use of short bonds. I have bonded many miles of track in this manner, and used the 12in. bonds and had no trouble. In girder rail I prefer to drill the holes through the flat tram taper ream the holes from above, and deeply countersink; then pass the rail bond up from beneath, and head up the ends till the taper and countersink are completely filled. This method has one great advantage, in allowing every rail bond to be inspected at any time without disturbing the paving. The tracks of the Atlantic Avenue Railroad, in Brooklyn, were bonded in this way with No. 000 copper bonds, 8in. long between rivet centres, and they have given entire satisfaction. Rail bonds should, after being applied, be either heavily coated with shellac and asphaltum, or have a grooved strip of wood filled with asphaltum slipped around while the compound is soft. This will prevent corrosion.

Another important element of the return circuit, in such roads as do not pass the power house, is the main return. Whether earth circuit is used or not there should be a heavy connection from the generator or switchboard by the shortest route to the rails. Such a course is generally adopted, but the size of the conductor is apt to be too small. I have seen several cases of serious inadequacy in this direction, so much, indeed, as to heat the main return. The old rails can be advantageously used for the main return in many cases. When it comes to using a large number of heavy copper wires overhead or underground on the one hand, and on the other hand an equivalent capacity of old rails laid underground, the latter is much cheaper, and can be made entirely durable. The rails can be connected by heavy copper plates by riveting, the number of rivets being equal in carrying capacity to that of the rail and plate. The whole structure can be laid in a wooden trough filled with pitch, and will remain intact for an indefinite period. A one-rail line of this kind, composed of old 60lb. flat or centre bearing rail, is as good as a copper bar 1in. square, or six No. 0000 copper wires.

I am, therefore, led to the conclusion that the best return circuit is that which complies with the following requirements:—

1. Intrinsic resistance, low enough to need no help from earth.
2. Utilisation, to the utmost practical extent of the rails as the return conductors.
3. Rail bonds of the heaviest practicable size.
4. Rail bonds of the shortest possible length, consistent with due allowance for expansion and vibration.
5. Rail bonds made of a single piece of wire with integral rivets.
6. Rail bonds tightly riveted to the rails through holes freshly reamed immediately before bonding.
7. Rail bonds so placed as to permit convenient inspection.
8. Rail bonds protected against corrosion.
9. A very liberal use of heavy cross bonds from rail to rail direct, and in double track, extra heavy cross bonds connecting the two inside rails.
10. An underground main or trunk return from power house to track, and there connected to each line of rails, and low enough in resistance to carry the maximum current with but a nominal drop in potential.

Not one of these requirements is an extravagance, but, on the contrary, their proper application to almost any electric railway in the country would be of immediate and lasting benefit. In new constructions they would be a positive economy in first cost. There is not one of them which cannot be adopted in practice, and it seems obvious that their complete embodiment in any existing road would be immediately noticeable in the power house and eventually in the dividend.

CORRESPONDENCE.

PROF. POYNTING'S STILL MORE MODERN VIEWS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have not yet had time to read Prof. Poynting's articles except in the most hurried manner, and before I reply I must study them with the attention they deserve. Meanwhile you will permit me to thank him for his useful criticisms, and to express the hope that I may be able to utilise some of them in a hypothetical "future edition."

On the face of it I like his improvement of my model by adding to it a set of locomotive bars, as suggested in Article II. I was anxious to show that a current *need* be nothing progressive on Maxwell's theory, and perhaps I overstrained this point and made out that it *was* nothing progressive, thereby making my model more difficult to grasp and less simply consistent with what had gone before.

In Article III. I see he recalls us to the possibility of magnetic energy being potential and electric energy kinetic, instead of *vice versâ*, but this view of the matter has never been wholly absent, and I have felt that several of Lord Kelvin's theories inclined to it. I admit adopting the other as more Maxwellian, and on the whole simpler; but whenever we attain to the ultimate hydrodynamical solution the two views will practically become one.

There is just one point where I am able to say at once that I do not agree with him, and that is his objection to Ampère's theory because of its attribution of perfection to material atoms. I see no reason for postulating any dissipation of energy as occurring in the ultimate atom itself, though every reason for assuming it in an assemblage of atoms. Atoms seem to be perfectly exact in weight and modes of vibration. I say this (in spite of Mr. Crookes's "average" hypothesis) on the basis of Michelson's experiments and Maxwell's gas theory; they are perfect in elasticity (though I admit that this statement is incomplete); and I see no reason why they should not be perfect in conductivity. The recent measurements of Dr. Fleming on the conductivities of metals at temperatures of boiling oxygen seem, indeed, to countenance the possibility of even an assemblage of atoms constituting a perfect conductor if they are sufficiently nearly in contact with each other.

If Prof. Poynting adheres to his antipathy to perfection it will be an interesting position, having important bearings in many directions. Doubtless the question trends in the metaphysical direction, but so does all physics if you push it far enough. We shall have to learn not to be afraid of a reasonable kind of metaphysics if we are to attack fundamental problems.—Yours, &c.,

OLIVER LODGE.

October 24, 1893.

SEARCH-LIGHT INTENSITIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the report on the Electrical Congress of Chicago, in your issue of September 29th I read a remark on the "hundreds of million candle-power" of the World's Fair search lights. Having given the problem of search lights some attention myself, I beg to be allowed to explain a misunderstanding.

These enormous brilliancies of hundred millions of candle-power of large search lights are no exaggerations, but based on actual observation by photometer. But they are not the intensity of the arc lamp, but that of the reflected beam of light. The arc of 150 amperes, and 2cm. to 3cm. crater diameter gives some 50,000 c.p. as average intensity in the angle of 120deg. to 140deg., subtended by the reflector. The reflector collects the light rays and sends them out as a narrow beam, of say, 2deg. diameter. Hereby the area lighted by the arc is reduced in the proportion 120^2 to 2^2, that is 3,600-fold, and the intensity consequently increased—neglecting absorption, false reflection, &c.—3,600-fold giving $50{,}000 \times 3{,}600 = 180{,}000{,}000$ c.p. as the intensity of the narrow beam of light sent out by the reflector. Herefrom it is obvious that search-light intensities are really of the

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magnitude claimed of hundreds of millions candle-power. Approximately, the intensity in the beam of a search light is the intensity given by an arc of the diameter of the reflector as crater diameter. But such an arc would give this intensity over the whole sphere or half sphere, while the search light gives it only in a narrow beam.—Yours, &c.,

Lynn (Mass.). CHAS. P. STEINMETZ.

ALTERNATING-CURRENT DISTRIBUTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Since the appearance of Prof. Robinson's valuable "Comparisons between the different systems of distributing electricity," I have weekly been expecting the realisation of the prophecy with which you heralded the appearance of that article, namely, that "endeavouring, as he does, to hold an impartial position, he is, of course, sure to be attacked by some alternate-current men." I am afraid this suggestion might lead unthinking persons to the conclusion that one of the recognised properties of alternating currents is to render the advocates of their employment peculiarly liable to irritation whenever they encounter fairness and impartiality in argument. But as a considerable time has elapsed without any expression of opinion from the "alternate-current men" as regards Prof. Robinson's article, such an effect of alternating currents on the nervous system may, I think, pending further investigations, be not unreasonably denied. The seat of irritation is much more probably to be found in the more satisfactory balance-sheets which the continuous-current supply companies have hitherto usually been in a position to issue. The wonderful improvement of the Metropolitan Electric Company, however, in this respect which the past year has witnessed, leads both to the conclusion that this state of affairs may undergo modification in the future, and also that Prof. Robinson's characterisation of the distributed transformer system as "obsolete" may stand in need of some slight alteration. "Obsolescent" would, I think, be a better word to describe the manner in which it is at present usually carried out. The point of view which "alternate current men" who are abreast of the times are most likely to take up in regard to Prof. Robinson's survey is one of surprise that he should have omitted all mention of recent improvements in connection with the system which promise to effect a decided revolution in the efficiency of distribution by separate transformers as compared with other methods, and in particular with the system of transformer sub-stations to which Prof. Robinson very naturally gives preference over the old system of distributed transformers. By attaching to each transformer an automatic switch (as described, I believe, in a recent number of *The Electrician*) so constructed that whenever the secondary circuit is closed (say even through a single 8-c. p. lamp) the primary of the transformer is thrown into connection with the mains, while when all the lights are turned out this connection is automatically severed, the constant day-loss when on open secondary through idle or "magnetising" current is completely eliminated. Prof. Robinson takes the all-year efficiency of separate transformer distribution under the most favourable conditions at 66 per cent. as a maximum—an estimate slightly in excess of that given by Prof. Fleming. We shall not be greatly in error if we assume in a town district, taking the different classes of customers one with another, that the transformers are on open circuit year in year out for 20 hours out of the twenty-four, *i.e.*, that the consumer uses the light for an average of four hours per diem. Again, taking one consumer with another, we may assume that transformers run at about half-load (on the average) during the time the consumer is using the light. Now it is perfectly possible to obtain transformers with a half load efficiency of upwards of 90 per cent., and as the losses due to fall of E.M.F. over the areas in which comparisons with the sub-station system or continuous current distribution can be instituted are practically negligible, the elimination of idle or "magnetising" current in the yearly account means a possible all-year efficiency of upwards of 90 per cent. as against 66 per cent. on the "obsolete" system of distributed transformers left permanently in connection with the mains.

It is not, however, with this obsolete system that the automatic disconnection system has to compete, but, as will be apparent from Prof. Robinson's Paper, with the system of distribution by sub-stations. Let us consider for a moment what degree of efficiency is in this case attainable. Prof. Robinson puts the idle or magnetising current at 1 per cent. of the three-fourths load current. This means that a 25-H.P. transformer takes 142 watts on open circuit. This is an exceedingly low estimate, and I do not think I need fear contradiction from practical men if I assert that most of them would be extremely glad to be able to procure a few 25-H.P. transformers that were as economical. Let the estimate pass, however. What does it work out at? The average time, summer and winter, that the 25-H.P. transformer is on open circuit will, of course, be a good deal less than is the case with separate transformers. In a district in which shops and private houses are fairly equally divided it may practically be taken at 18 hours per diem. At the same time it will be found that only in the case of exceptionally fortunately situated sub-station transformers will the average load exceed one-fourth. With a one-fourth load efficiency of 86 per cent. (a high figure) this gives an all-year efficiency (with an idle current of 142 watts) of 82·6 per cent., which estimate, however, must be further reduced by the fall of E.M.F. on the low-pressure mains. Assuming that the *average* or mean distance of the customers is 100yds. from the sub-station, this will amount to 2½ per cent., and the efficiency of distribution will come out at 80·5 per cent.

These figures are, I think, sufficient to show that an economy of at least 10 per cent. may easily be effected by the automatic disconnection system as compared with the sub-station system. I say at least, for while most station engineers will, perhaps, admit that a 25-H.P. transformer, taking only 142 watts on open circuit, may yet be put on the market, they would probably unanimously declare that they have not yet been privileged to form its acquaintance.

That there would be much to be said for the distributed transformer system, and that its heaviest disadvantage would be removed, if only the transformers could be prevented from taking current on open circuit, is shown by the amount of attention directed by Mr. Swinburne and others to attempts to eliminate the idle current by the use of condensers in shunt. This it is, of course, perfectly possible to do when the right capacity for the condenser is hit upon, though, as Prof. Fleming has pointed out, the loss is in all probability merely shifted from one place to another, while the waste due to the condenser when the transformer is loaded is very considerable. This probably explains the fact that the condenser has not come into practical use, and we may conclude that, if adopted, it would probably diminish the coal bills but little, and would certainly not be in a position to effect anything like the amount of economy attainable by means of the automatic disconnection system.

Some fears were entertained at first that the "rush of current" on cutting in a transformer, to which Prof. Fleming has drawn attention, might have a prejudicial effect upon the insulation of the transformer; but it has been found that the rush never occurs when the secondary is closed *before* the primary. By arranging that this always takes place, the one practical objection to the system has been removed, and nothing now remains to prevent the alternate-current companies from taking advantage of the very considerable economies which it affords.—Yours, &c., R. N. LUCAS.

October 21.

ELMORE'S WIRE MANUFACTURING COMPANY (LIMITED).—A meeting of the shareholders of this Company was held yesterday (Thursday) at Winchester House, London, E.C. No public notice of the meeting being held had been issued, therefore our reporter was not present.

INTERNATIONAL OKONITE COMPANY (LIMITED.)—A meeting of the shareholders of this Company will be held at the Cannon-street Hotel, E.C., to-day (Friday) at 12 o'clock.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The Directors of this Company state that, owing to the critical state of affairs in Brazil, they will be unable to recommend a dividend for the half-year ended June 30th last. They have placed £12,000 to reserve fund, and propose to carry forward £7,679 to the current half-year.

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TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1893 Edition of "'The Electrician' Electrical Trades' Directory and Handbook" contains over 1,000 pages, several new and handy features having been added. Price 7s. 6d., post free 8s. 3d.; abroad 8s. 10d. *Comparison with any similar electrical publication is specially invited.*

The 1894 Edition is in preparation, and will be published in January next. New names, alterations of addresses, &c., are received at any time, but the Directory blanks and circulars are not sent out until later in the year, in order that the most recent, and consequently the *correct*, addresses *only* shall appear in the book. Full printed particulars can be obtained, post free, from "The Publisher," *Electrician* Office.

"Drum Armatures and Commutators."—This book, which is written by Mr. F. Marten Weymouth, and is the latest addition to *The Electrician* Series, is now ready, and will be sent direct on receipt of the published price, 7s. 6d., or it may be obtained from any bookseller. A prospectus will be forwarded free on application.

Tenders Invited.—*Extension of Time.*—It will be seen by our advertisement columns that the time for sending in tenders for the various contracts in connection with the electric lighting of the borough of Sunderland is extended to Friday, November 17th.

——— The Electric Lighting Sub-Committee of the Corporation of Newport invite tenders for the supply and erection of engineering and electrical plant and apparatus for the equipment of the Municipal Electricity Works of the County Borough of Newport. The plan of buildings, map, specifications, &c., can be obtained at the offices of Mr. Robert Hammond, consulting engineer to the Corporation, 117, Bishopsgate street, London, E.C., on and after Monday, the 30th inst., and tenders must be addressed to Mr. Albert A. Newman, Town Clerk, the Town Hall, Newport, (Mon.), not later than Monday, November 20th. Further particulars are given in our advertisement columns.

——— Tenders are invited for the wiring, provision and fixing of the electric light fittings, &c., for the electric lighting of the Midland Deaf and Dumb Institution, Derby. The specification and forms of tender may be obtained from Messrs. Bramwell and Harris, and tenders are to be in by noon on November 6th.

Bankruptcy.—In the case of William Andrews, electrician, lately trading at 118, Hungerhill-road, Nottingham, the liabilities are given at £495 and the assets at £423, leaving a deficiency of £72. The bankrupt has taken out several patents for improvements in railway signalling apparatus, and a company (the Railway Electric Fog Signal Syndicate (Limited) was incorporated with a nominal capital of £25,000, in £1 shares, to purchase and exploit the patents. The bankrupt has transferred the great majority of his shares to other persons, and now possesses only 900, which he estimates to be worth £225. After making all deductions, his entire interest in the patents is represented by an estimated surplus of £390, but the Official Receiver thinks it extremely doubtful whether this sum would actually be realised. The public examination of the bankrupt is fixed for November 3rd.

The New Incandescent Arc Light.—Under this title the Royal Arc Electric Company, of 143, Liberty-street, New York, are introducing the lamp described by Mr. L. B. Marks before the Chicago Congress, and illustrated in *The Electrician*, p. 503 of the present volume.

Serious Theft of Electrical Plant.—Recently the Cardiff electric light station was broken into, and property amounting to a considerable value was stolen. The property chiefly consisted of exciting fluids which are not usually to be found even in a battery station, and comprised six bottles of champagne, a pint of brandy, *half* a bottle of Scotch whisky, four bottles of hock, besides nine bottles of ginger beer and a quantity of Apollinaris water. In addition, the plant at the Cardiff electric works was diminished to the extent of 25 plates, though it is not clear if these were L-type plates or the ordinary dinner-table article.

Aluminium Solders.—Mr. W. Archibald Briggs, of 87, High-street, Dundee, sends us a circular announcing that, as the result of recent experiments, he is now in a position to offer a more fusible solder than hitherto, suitable for the very thinnest work. Mr. Briggs also claims that he has been successful in producing an aluminium more easily solderable than ordinary commercial aluminium. He claims for the combination superior results to those hitherto obtained.

Bogus Electric Light Men.—A respectably dressed man, who gave the name of Jones was charged at the Westminster Police Court on Friday with being on the enclosed premises of the Westminster School, Dean's-yard, for a supposed felonious purpose. He was seen to enter a room in the building, and when followed and interrogated as to his business, he said he had been sent by a West End firm of electrical engineers, whose name he mentioned, to look after the electrical appliances. He was detained, and inquiries were made of the firm mentioned, who said they knew nothing at all about him. A detective-inspector said that the police had had for the last three years many complaints of larcenies by men calling at mansions and pretending that they were sent to look after the electric light fittings. The prisoner was remanded.

Wilful Damage.—A man named M'Queen was remanded on Tuesday by Mr. Headlam, the Manchester City Stipendiary, on a novel charge of doing wilful damage. On the 20th inst. workmen were laying down an electric light installation at the Mosley Hotel, Piccadilly. A dispute occurred amongst them, and in the course of it prisoner, who had been discharged, is alleged to have torn away the fuse attached to the Corporation main supply, with the result that the hotel, which had been temporarily lighted up, was thrown into complete darkness. The fuses on the staircases leading from the basement were also severed, and it was stated that the hotel, the erection of which has only just been completed, was in great danger of being burnt down owing to the wires coming in contact with the woodwork.

Brewers' Exhibition.—An extensive exhibition of machinery, apparatus, and accessories used in the brewing and licensed victuallers' businesses has been held at the Agricultural Hall during the present week. There is again an almost entire absence of electrical exhibits and lighting, although the exhibition appears to be a favourable opportunity for the display of a variety of electrical appliances suitable for shop, office, and factory lighting, and also for the lighting and fitting of billiard-rooms, public-house bars, &c. There is, however, a good display of engineers' tools and general engineers' stores, made by Messrs. W. H. Wilcox and Co.; Mr. E. S. Hindley shows several examples of small steam engines: and the gas-engine makers are also in evidence. The exhibition has been a very successful one throughout.

Messrs. Drake and Gorham.—This firm have received the contract for installing the electric light in the offices of the Rock Life and Fire Insurance Company in New Bridge-street, E.C.

Messrs. Vaughan and Brown.—We understand that this firm have made arrangements for lighting the Agricultural Hall during the two forthcoming exhibitions, viz., the Confectioners', and the Stanley Shows. The hall is to be illuminated by 50 arc lamps, the current for which will be generated by a Brush dynamo driven by a 20 H.P. gas engine.

Papier-maché Covering for Pulleys.—We have received from Mr. W. S. Dougall, of Radcliffe-on-Trent, some particulars and price-list of his patent pulley covering, which, it is claimed, prevents slipping of pulleys, and consequently saves loss of power from that source.

Messrs. John Wilson and Son.—We are informed that this firm, whose works are at Johnstone, have acquired the works and business of Messrs. William Robertson and Co., machine tool makers, of Johnstone, which they are placing under the supervision of Mr. Alexander Wylie who, for the past thirty years has been connected with the late firm of Messrs. J. and W. Weems. Messrs. Wilson and Son are prepared to continue the manufacture of the various specialities of Messrs. J. and W. Weems, especially those connected with machinery for the manufacture of lead pipes, block tin pipes, sheet lead, and for the covering with lead of electric cables of all kinds.

Messrs. Cox-Walkers.—This firm send us their new catalogue (Part III.), dealing with electric tell-tales, fire alarms, lightning conductors, mining signals, indicators, and bells. Several forms of the specialties are illustrated.

Dynamo Brushes.—The Boudreaux Dynamo Brush Company are introducing into this country their new foliated rolled-metal dynamo brushes (invented by M. Boudreaux, of Paris). Price lists can be obtained at the offices of the Company, St. Martin's House, 1, Gresham-street, E.C. It is claimed for these brushes that they are extensively used on the Continent, that they do not wear away the commutator, keep cool, have a long life, and that by their use, a smooth commutator will run for several days without requiring attention.

Barnet.—The Local Board at their last meeting appointed a committee to inquire into the question of the electric lighting of the town, and to consider the advisability of the Board undertaking the work under their Provisional Order or of transferring their powers to a company.

Bournemouth.—The Town Clerk reported at the last meeting of the Town Council that formal application had been made to the Board of Trade for an electric lighting licence, and it might be expected to be issued in three or four months' time. The Parks

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Committee had had under consideration the report of the Surveyor, estimating the cost of the illuminating by electricity of the proposed *fountains* in the gardens at £204. 9s. each, and they recommended that the scheme be abandoned. Regret was expressed at the decision of the Committee, and after some discussion, the Surveyor saying that if the proposed illumination were postponed it would be very difficult to carry it out at a subsequent time, it was decided to refer the proposal back to the Committee for further consideration.

BRADFORD.—The Electricity Department of the Corporation report that their income for the past financial year has been £8,399, and the expenditure £3,913, showing a profit on trading account of £4,486. Sinking fund and interest charges amount to £2,863, leaving a net profit for the year of £1,623. The working of the department for the previous year resulted in a net loss of £354, which, deducted from the present year's net profit, leaves a total net profit on the two years' working of £1,269.

CAMBERWELL.—Mr. Manville some time since having been appointed by the General Purposes Committee of Camberwell to report to them as to the best means of introducing an electricity supply into the parish of Camberwell, and the report having been presented and read, it was resolved that it should form the basis of a lecture. This was delivered recently at the Camberwell Vestry Hall, and was illustrated by lantern views and experiments.

CASTLEFORD.—The Electric Lighting Committee reported at the last meeting of the Local Board that Mr. Hammond had offered them terms for advising the Board on the best means of lighting the district by electricity, preparing plans, and doing all the necessary work up to the time of making application to the Board of Trade for a Provisional Order. The Board decided to accept Mr. Hammond's offer.

CHELSEA.—The fourth annual report of the surveyor to the Chelsea Vestry (Mr. T. W. E. Higgins) contains the following remarks upon the electric lighting of the district:—"At the beginning of the year the Cadogan Electric Company was supplying electricity without an Order. The St. Luke's (Chelsea) Electric Lighting Company had obtained an Order, but had not satisfied the Board of Trade as to their financial position. The time for satisfying the Board of Trade having expired, the Vestry agreed to an extension of time, so as to enable the St. Luke's (Chelsea) Company—which appeared to be the Cadogan Company under another name—to satisfy the Board of Trade. They did not, however, do so, and as complaints were received of failure to supply light, the Board of Trade, after receiving a representation from the Vestry, cancelled the Order, and the Chelsea Electricity Supply Company are now supplying the houses formerly supplied by the Cadogan Company. As regards the cancelling of this order, the action taken by the Board of Trade is considered most satisfactory. It has always seemed to be a mistake to have allowed a private company, acting without statutory authority, to break up the public streets, and supply electricity without proper supervision. It is true that the Cadogan Company entered into an agreement with the Vestry, and in virtue of that agreement they opened the streets, but that agreement did not enable the Vestry to control the Company in the supply of electricity, and as a result of this absence of control great inconvenience was caused to most of the persons who obtained their current from this Company. When companies obtain statutory powers to open streets and supply electricity they are, very justly, compelled to fulfil certain obligations in return for their privileges; but under their agreement with the Vestry (which was an illegal one) the Cadogan Company obtained privileges without corresponding obligations being enforced. This Company during some period of their existence were supplying electricity at high pressure. The Board of Trade enforce certain restrictions and regulations upon any company which obtains an Order or Act of Parliament before supplying electricity, and the irregulations as regards a high-pressure supply are of great value for the public safety; but as the Cadogan Company had no licence, Order, or Act, no restrictions or regulations were enforced, or could be enforced, by the Board of Trade, except as regards their overhead wires, and the Vestry had no means of knowing whether the supply of electricity by that Company was at a constant voltage, whether it varied, or whether any attempt to regulate the supply was made."

CHURCH LIGHTING.—The church of St. Mary-at-Hill, in the City of London, is to be lighted by the electric light.

CLECKHEATON.—The Local Government Board have sanctioned the borrowing of £670 for the electric lighting of the public offices.

CLERKENWELL.—At the last meeting of the Vestry a letter was read from Mr. Emile Garcke on behalf of the County of London Electric Lighting Company, asking the Vestry to reconsider their decision refusing consent to the extension of time for carrying out the provisions of their Lighting Order, and stating that the work would be commenced in January or February next. The Vestry, however, decided to adhere to their former decision, viz., that consent would not be given until there were absolute indications of the work having been started.

DEWSBURY.—At the last meeting of the Board of Guardians the Sub-Committee appointed to consider the electric lighting of the Union premises recommended that an electrical expert be engaged to advise the Board, which was agreed to.

EALING.—The Local Government Board inquiry into the application of the Local Board for permission to borrow £25,000 for the purposes of the electric lighting of the district was to have been held yesterday (Thursday).

FALMOUTH.—Messrs. Veale and Co. (Limited) have prepared a report for the Town Council on the electric lighting of the principal streets of Falmouth, and it will be taken into consideration at an early date.

FLEETWOOD.—At the last meeting of the Improvement Commissioners the Clerk reported that the Board of Trade had granted a further extension of six months from the 20th inst. of the Fleetwood Electric Lighting Order. The report of the Lighting Committee, which had been delayed in consequence of illness, was presented. The committee were anxious, seeing that the installation would cost some thousands of pounds, that nothing should be done until they had before them a scheme, which would benefit the town and be a source of revenue. They had now formed an idea of what was suitable for Fleetwood, and they hoped within a very short time to be able to lay before the Board tenders for a complete scheme for public and private lighting at less cost than had yet been effected in any other town, and which at the same time would be second to none in efficiency. The report suggested that the central station should be erected in the Town's-yard, that the present street lamps be used as far as possible for electric lighting, and that a low-tension system with accumulators form part of the scheme, the motive power to be obtained by means of producer gas. The report was accepted, and it was anticipated that the whole matter should be placed before a public meeting after the Board had considered the scheme.

GRIMSBY.—The Public Light Committee of the Grimsby Corporation resolved on Monday to agree to a request from Mr. Hammond that he be allowed to attend before them and explain his views upon the subject of electric lighting. The interview is to take place to-day (Friday).

HALLE (GERMANY).—The Halle electric tramway, the property of the Allgemeine Elektricitäts Gesellschaft, is to be sold to the Halle Tramways Company for 800,000 marks (about £40,000). This does not include permanent way and depot, which belong to the town. A further sum of about £18,500 is to be paid for the electrical plant on the Company's lines.

HALIFAX.—The Town Council have confirmed the minutes of the Gas and Electric Lighting Committee declining the terms on which the Halifax Mutual Electric Light and Power Company proposed to continue the supply of the electric light for 12 months, whilst the Corporation scheme was being installed.

HAMILTON.—The Caledonian Electric Supply Company having requested the Town Council to approve their application to the Board of Trade for a Provisional Order, the Council have decided to withhold their consent, and to apply for an Order themselves.

HANLEY.—The Town Council have adopted a plan, prepared by the Borough Surveyor, providing for the extension of the electric light mains at a cost of £3,100, £1,800 of which is provided for in the existing contract.

HUDDERSFIELD.—The report of the Electric Lighting Committee submitted to the last meeting of the Town Council contained the following:—"The following report submitted by the engineer was approved: The sub-committee appointed, consisting of the Mayor, Chairman, and Vice-Chairman, visited London on October 3rd, and proceeded, with Councillors Sterry and Munroe, to the works of the Indiarubber, Gutta Percha, and Telegraph Works Company (Limited), Silvertown, where the electric light cables were very carefully tested, and found to have an insulation resistance below that specified. The cables have, therefore, been rejected, and others are being made. The Mayor, Chairman, and Vice-Chairman, on the following day, visited the works of the Brush Electrical Engineering Company (Limited), at Loughborough, and examined the new plant which is in course of preparation. Considerable surprise was expressed at the backward state of the plant, which it seems scarcely probable can be at work by the end of October, which is the time specified. Instructions were, therefore, given to the engineer to write the Brush Company and remind them of the fact that they were under a heavy penalty to deliver by the time specified." The minutes of the Committee were confirmed by the Council.——Messrs. Winfields (Limited) have just completed the fittings for the electric lighting of the Town Hall and municipal buildings, including a number of handsome brass electroliers, which have been carefully designed in perfect harmony with the decorations of the buildings.

KILLARNEY.—The dispute as to the lighting of the town reached a further stage on Saturday, when at a meeting of the Town Commissioners, the Chairman signed the minutes of the proceedings of

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the previous meeting at which the tender of the gas company was accepted, nothwithstanding that the Killarney Electric Light Company had tendered at a much lower figure. A written protest was handed in by a member, and legal proceedings are threatened. ——The Board of Control at Dublin having been requested to supply the Governors of the Killarney District Lunatic Asylum with the reason why the former Board had declined to sanction the scheme for lighting the Asylum by electricity, have replied that they did not feel justified in sanctioning the installation, which would involve considerable expense, until the Company who made the proposal had completed the necessary works for supplying the current required. The Board of Control say, in addition, that they are fully alive to the many advantages of lighting the Asylum by electricity, and they will be prepared to reconsider the project when the Electric Light Company are in a position to satisfy them on the point referred to.

LARNE.—The Town Commissioners sat specially on Friday to consider tenders for the lighting of the town which had been received from Messrs. J. E. H. Gordon and Co. (offering to renew the electric lighting) and from the Gas Company; but neither offer being on the basis of the Commissioners' specification, the tenders were not considered, and the two Companies are to be given until the first meeting of the Commissioners in December to prepare fresh tenders.

LIVERPOOL.—At the annual meeting last week of the Junior Reform Club a general desire was expressed that the club should be lighted by electricity, and the attention of the new committee was drawn to the matter.

QUEENSTOWN.—Negotiations are proceeding between an electric light supply company and some of the ratepayers of Queenstown with reference to providing the town with electric light, and the matter will probably come up before the Public Commissioners in a short time.

POPLAR.—At the last meeting of the Board of Works a letter was read from Mr. Cooper, stating that the Poplar Electric Lighting Supply Company were willing to take a transfer of the Powers granted to the Board by the Poplar Electric Lighting Act under the usual conditions. The Company would pay the Board £250 for cost of securing those powers, and would also pay the cost of the transfer, and would take upon themselves all the powers and liabilities incurred by the Board under the Order. The Board would also have the option of purchasing the undertaking, subject to reasonable notice.

SOUTHAMPTON.—The Harbour Board have appointed Mr. Geo. E. Taylor as engineer in charge of the two electric cranes on the Town Quay.

TOWCESTER.—An endeavour is being made to introduce the electric light into this town, and as the result of a canvass of the principal inhabitants and shopkeepers there seems no doubt but that further steps in the matter will soon be taken.

YEADON.—The Local Board have applied to the Local Government Board for a Provisional Order for power to light the town by electricity, and have also applied for sanction to borrow £7,000 for this purpose.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

October 4, 1893.

18,596. W. MARTIN. Birmingham. Improvements in the means or mode of protecting insulators as employed for electrical purposes or appliances.

18,602. C. D. ABEL. London. Improvements in telephone switchboards. (Société Générale des Téléphones, France.)

18,609. J. G. FOSTER. London. Improved telephone attachment.

18,610. P. R. J. WILLIS. London. Improved electrical heating apparatus. (C. E. Roehl, S. Z. Mitchell, and E. P. Wetmore, United States.)

October 5, 1893.

18,620. E. MAYER. London. Improvements in pocket batteries.

18,626. J. B. KING and T. E. BICKLE. Plymouth. Improvements in electrical conductors.

18,641. J. B. TORRES. London. Improvements in and connected with the smelting, reduction, refining, dephosphorisation and desulphuration of ores, mattes, slags, metals, and alloys; and constituting of metallic alloys.

18,661. F. G. P. PRESTON. London. Improvements in electric telegraphs for steering, engine room, and other signalling purposes.

18,674. THE PHONOPORE COMPANY (LIMITED) and C. E. SPAGNOLETTI. London. Improvements in electrical receiving instruments and relays.

18,690. C. G. PICKING. London. Improvements in conduits for electric conductors.

October 6, 1893.

18,734. H. P. OLSEN. London. Improvements in electric meters.

October 7, 1893.

18,805. B. DAVIES. Liverpool. Improvements in electric measuring instruments.

18,841. THE EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED) and JOHN AMBROSE FLEMING. London. An improvement in incandescent electric lamps and sockets.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1892.

16,906. HARPER. Audible telegraphs.

16,919. SWINBURNE. Electric motors.

17,491. STEVENSON. Applying electricity to the head.

19,874. DAVIS and COLLINS. Electric lamps, &c.

20,214. BOULT. (Knöfler and another.) Electrolytical apparatus.

20,666. RABBIDGE. Electromagnetic alarm.

1893.

6,241. DUNCAN. Electricity meters.

6,517. JENKINS. Electric currents for heating, &c.

12,291. BOULT (Woodward). Secondary batteries.

12,577. MCGREGOR. Electric traction.

12,805. THUM. Electric lighting.

14,485. NALDER and others. Electric switches.

14,516. KREINSEN. Electric furnaces.

15,343. OSENBERG. Electric lamps.

15,957. LA SOCIÉTÉ ANONYME POUR LA TRANSMISSION DE LA FORCE PAR L'ÉLECTRICITÉ. Electromotors.

15,963. ZEITSCHEL. Electric indicators.

COMPANIES' MEETINGS.

Eastern Extension, Australasia and China Telegraph Company (Limited).

The following is the report of the Directors for the half-year ended June 30, 1893, to be submitted to the fortieth ordinary general meeting, to be held at Winchester House, Old Broad-street, E.C., on Wednesday next, November 1st, at 2 o'clock:—

The gross receipts for the half-year ended June 30, 1893, including Government subsidies, have amounted to £257,986. 13s. 5d. against £246,988. 16s. 6d. for the corresponding half-year of 1892. The working expenses, including £21,649. 3s. 3d. for cost of repairs to cables and expenses of ships, absorb £78,229. 19s. 3d., against £79,281. 11s. 10d. for the corresponding period of 1892, leaving a balance of £179,756. 14s. 2d. From this is deducted £3,968. 15s. 5d. for income-tax, £32,171. 1s. 1d. for interest on debentures, debenture stock, contribution to sinking fund and special expenditure, leaving £143,616. 17s. 8d. as the net profit for the half-year.

Two quarterly interim dividends of 1½ per cent. each, amounting to £62,500, have been paid for the half-year under review, leaving £81,116. 17s. 8d. to be carried forward.

The working of the Australian tariff arrangement for the second year of guarantee ended April 30th last, has resulted in a loss of £43,558 as compared with £55,040 for the first year, and in accordance with the terms of the agreement, one-half of the loss or £21,779 has been made up by the guaranteeing Colonies and the other half borne by the associated companies.

Your Directors have to record with deep regret the lamented death, on May 7th last, of their much esteemed and valued colleague Sir James Anderson, who had been connected with the Company since its formation. Under the powers given to them by the Articles of Association they have elected Sir Albert J. Leppoc Cappel, K.C.I.E., to fill the vacancy thus occasioned.

Your Directors have to report that the Chairman having performed the duties of Managing Director since the death of Colonel Glover in 1891 without salary, they have added to the Chairman's remuneration the salary formerly paid to the Managing Director, in consideration of the ever increasing duties and responsibilities falling upon the management.

The Company's maintenance ships have, as usual, been employed on various cable repairs during the half-year under review; but owing to most of the cables being duplicated, the revenue has in no instance been materially affected.

Monte Video Telephone Company (Limited).

The following is the report of the Directors, to be presented to the shareholders at the annual general meeting, to be held at the offices, No. 96, Gresham House, Old Broad-street, E.C., on Tuesday, October 31st, at 12 o'clock:—

Your Directors present herewith the audited statement of accounts for the year ended July 31st last, showing a net profit for that period of £6,895. 17s. 6d., which, including the amount of £1,879. 5s 3d. brought forward from last year, leaves an available balance of £8,775. 2s. 9d. after providing for all working expenses in Monte Video and London, and after writing off £49. 18s. 7d. for proportion of preliminary expenses, and

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£35. 5s. 8d. for depreciation of furniture at head office and in Monte Video. A comparison of the present accounts with those of last year shows a decrease of £1,100 in the working expenses at Monte Video, and of £275 in the London office expenses, making together a decrease in expenses of nearly £1,400, while the falling-off in the total value of subscriptions is only £700, and the net profit for the twelvemonth, after making ample allowance for bad and doubtful debts, is close on £500 more than for the preceding like period. Considering the continued state of depression prevailing in business circles in Monte Video during the whole of the period under review, your Directors think these figures will appear to you satisfactory under the circumstances.

The central premises in Monte Video have now become the unencumbered property of your Company, the final instalment of the purchase, money having been paid on March 6th last. The total sum paid out of this year's earnings for purchase-money and interest is £5,504, and in addition to this expenditure it has been deemed expedient to open up a new branch to Barra, a small hamlet, distant about ten miles from Monte Video, at the mouth of the river Sta. Lucia, and other new lines have been laid at the request of subscribers, so that the total outlay for improvements and additions to your property stands at £1,637, making together £7,141 paid out of revenue: therefore the Directors do not think it advisable to declare any dividend, and they recommend that the sum of £5,000 be placed to the reserve account, that £3,000 be added to depreciation fund, and that £775. 2s. 9d. be carried forward to next year.

The number of paying subscribers is now 1,383, showing an increase for the year of 53, and with a return to more normal conditions in commercial circles generally in Uruguay, there is no doubt this number would be substantially increased.

The Directors have to announce that the Committee of the London Stock Exchange granted, on June 12th last, an official quotation to this Company's shares, both Preference and Ordinary.

It having been suggested by several large shareholders that a fourth Director might be added to the Board, this matter will be submitted to the meeting for consideration. In accordance with the Articles of Association, Mr. E. F. Powers retires *per rotâ* from the Board, and, being eligible, offers himself for re-election. The auditors, Messrs. Gérard Van de Linde and Son, also retire, but offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

CANTERBURY ELECTRICITY COMPANY (LIMITED).—This Company was registered on October 18th, with a capital of £50,000, in £5 shares, to carry on the business of electrical engineers, electricians, suppliers of electricity, contractors, mechanical and chemical engineers, and of producing light, heat, sound, motive-power, or other force by electricity, galvanism, magnetism, or otherwise, and to manufacture or deal in plant, machinery, implements, &c., relating to the objects of the Company. The subscribers are:—

	Shares.
B. Broadhurst, Minerva-road, Kingston-on-Thames	1
George E. Zeden, Shandon Lodge, Coventry Park, S.W.	1
Frank E. Beeton, 76, Woodsome-road, N.W.	1
F. Hodson, 161, Kennington-road, S.E.	1
W. D. Brightman, 7, Queen Anne-terrace, Bowes Park, N. ...	1
R. Percy Sellon, 49, Queen Victoria-street, E.C.	1
A. J. Lawson, 63, Bedford-gardens, Kensington, W.	1

The number of directors is not to be less than three nor more than seven.

DOVER ELECTRICITY COMPANY (LIMITED).—This Company was registered on the same date, and with the same amount of capital, similar objects, and the same signatories, as the Canterbury Electricity Company (Limited), given above.

ENGLISH ELECTRIC MANUFACTURING COMPANY (LIMITED).—This Company was registered on October 23rd, with a capital of £5,000, in £1 shares, to carry on the business of electrical and mechanical engineers, electricians, suppliers of electricity, and manufacturers of, and dealers in, electric, galvanic, magnetic, telegraphic, telephonic, and other appliances and apparatus; to generate, produce, accumulate, transmit, distribute, and supply electricity, magnetism or similar agency, for all purposes for which the same may be used; to erect, fix, lay down, construct, connect, provide, supply, let on hire, remove, and keep in repair, cables, wires, lines, dynamos, accumulators, meters, fittings, lamps, &c.; and generally to carry on the business of an electric apparatus manufacturing and electricity supply company in all or any of its branches. The subscribers (with one share each) are:—M. J. St. C. Griffin, Liverpool; John H. Hirst, Huddersfield; Joseph Hales, Leicester; Archibald Anderson, Southport; J. W. Parsons, Cardiff; F. H. Lloyd, Mansfield; M. N. Hales, Leicester. Joseph Hales is the Chairman of Directors.

GEORGE ADAMS AND SONS (LIMITED).—This Company has been registered with a capital of £100,000, in £10 shares, to acquire the business of galvanised iron and steel manufacturers and ironmasters, carried on by George Adams and Sons at Bilston.

HART, SON, PEARD AND CO. (LIMITED).—This Company has been registered with a capital of £35,000, in £10 shares, to acquire, as a going concern, and carry on, the business of ironmongers, iron and brass founders, metal workers, &c., as now carried on at Birmingham and London under the style of Hart, Son and Peard.

RAMSDEN, CAMM AND CO. (LIMITED).—This Company has been registered with a capital of £50,000, in £10 shares, to acquire the business of wire drawers, manufacturers, and galvanisers, carried on at Brighouse, Yorks, under the styles of Ramsden, Camm and Co., and S. H. Byrne, and to carry on the business of wire drawers, manufacturers and galvanisers, iron and brass founders, metal workers, mechanical engineers, machinists, &c. The first Directors are Isaac Lancaster, William H. Shepherd, Joseph Hey, Hophni Bland, and one other to be elected by the above-mentioned Directors.

WILLIAM MUIR AND CO., MANCHESTER (LIMITED).—This Company has been registered with a capital of £80,000, in £5 shares, to acquire the business carried on at Strangeways (Manchester) and elsewhere by William Muir and Co., and the works and property held therewith, and to carry on the business of machinists, machine and engineering tool makers, mechanical engineers, iron and brass founders, metal workers, &c. The first Directors are A. Muir, H. Garnett, and F. H. Garnett, A. Muir being Managing Director.

ELECTRIC FITTINGS HIRING AND MAINTENANCE COMPANY (LIMITED).—The first annual return of this Company, made up to August 21st and recently filed, shows that only the seven signatories' shares had been taken up out of a nominal capital of £200,500, divided into 40,000 Ordinary shares of £5 each, and 500 Founders' shares of £1 each. No calls have as yet been made.

ELECTRO-AUTOMATIC FIRE EXTINGUISHING COMPANY (LIMITED).—In reply to official inquiries as to the cause of the non-filing of the necessary returns, Messrs. Fox and Joy, of 59 and 60, Chancery-lane, London, W.C., write stating that General Marten, the promoter and vendor, left England immediately after the incorporation of the Company, and the very *raison d'être* ceased to exist in consequence.

ENGLISH ELECTRIC CARBON COMPANY (LIMITED).—The annual return of this Company, made up to July 24th, and recently filed, shows that 641 shares have been subscribed for and allotted, out of a total nominal capital of £10,000, in £10 shares. Upon 56 of these the full amounts have been called, and upon the remaining 585 shares a call of £5 per share has been made, resulting in a total payment of £3,485.

EXETER ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to October 7th, shows that out of a nominal capital of £20,000, in £10 shares, 1,100 shares have been taken up, of which 305 have been issued as fully paid. Upon the remaining 795 shares the full amounts have been called and paid. By special resolutions passed on September 23rd, and confirmed on October 14th, 500 Ordinary shares which were not issued were changed to "A," or Preference, bearing interest at 6 per cent. per annum, and the Articles of Association were altered in accordance therewith.

CITY NOTES, &c.

BRIGHTON AND HOVE ELECTRIC LIGHT COMPANY (LIMITED).—Suggestions were made at a recent meeting of the Debenture-Holders' and Creditors' Committee that a scheme for the reconstruction of the Company should be formulated, and we have received a copy of the proposed scheme. The subscribed capital and liabilities of the present Company are:—Ordinary shares of £5 each, in £15,005; First Mortgage Debentures, £15,000; unsecured liabilities, (about) £8,500; or a total of 38,505. Under the proposed reconstruction scheme the present shareholders are to submit to a reduction of the £15,005 in Ordinary shares to £7,505, entitling the holders to any profits after providing for interest on debentures and dividends on the two proposed classes of Preference shares; the creditors on unsecured accounts are to be allotted Second Preference shares to the value of their claims on outstanding accounts, entitling holders to a 6 per cent. dividend, after providing interest on debentures and for dividend on First Preference shares, and to rank in priority to the Ordinary shares as regards capital; the debenture-holders are to surrender half their holding in Debenture bonds, viz., £7,500, and to receive in exchange £7,500 in First Preference shares, in addition to shares for arrears of interest entitling holders to a dividend at the rate of 6 per cent. per annum after payment of interest on debentures, and to rank in priority to the Second Preference and Ordinary shares as regards capital; and £5,000 is to be raised in new capital on Six per Cent. Prior Lien Debenture Bonds, which will rank as a first charge on the property and undertaking of the Company in priority to the £7,500 debentures retained by the present debenture bondholders. The total subscribed capital of the Company under this reconstruction scheme would thus be £37,005.

CALLENDER'S BITUMEN TELEGRAPH AND WATERPROOF COMPANY. The Directors of this Company have declared an interim dividend (payable on November 1st) at the rate of 10s. per share.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended October 22nd were £807, as against £865 for the corresponding period of last year, being an decrease of £58. The total receipts for the half-year amount to £12,918, against £12,620 in the corresponding period of 1892, being an increase of £298.

CONTINENTAL ELECTRICAL DIVIDENDS.—The Geneva Electricity Works last year made a profit of over 300,000fr. (about £12,000); after placing about £7,000 to reserve the dividend is 5½ per cent. The Stettin Supply Company pays 5½, against 4¾ per cent. last year. The Berliner Elektricitäts Gesellschaft distributes 8½ per cent., against 7½ per cent. last year.

INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).—The Board of Directors of this Company have declared an interim dividend for the half-year ended June 30th last at the rate of 5 per cent. per annum, free of income-tax, payable on and after 1st proximo.

PRETORIA LIGHTING COMPANY (LIMITED).—The Directors' report presented to the fourth annual meeting of this Company, held at Pretoria,

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on September 1st, showed a profit on the year's working of £2,000, which was considered highly satisfactory. The electric light was growing in favour, and nearly every important building in the town was supplied with current by the Company. The report and accounts were adopted.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended October 20, 1893, after deducting 17 per cent. of the gross receipts, payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,493.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 18.		Price Wednesday, Oct. 25.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 25.	
								£ s. d.		Highest	Lowest
			TELEGRAPHS								
£1,134,640	Stock	12/6	Anglo-American	45	47	43	45	6 2 3	Jan., Apr., July, Oct.	45⅝	45¼
£2,932,680	Stock	25/0	Do. Preferred	84	86	80	82	6 14 2	" "	85⅞	80½
£2,932,680	Stock	5/0	Do. Deferred	8	8¼	7½	8	..	.. ..	8⅛	7⅞
£195,100	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	100	103	100	103	3 17 8	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	12	12⅛	12	12¼	5 4 0	Mar., June, Oct., Dec.	12⅜	12⅛
£36,400	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	101½	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107	111	107	111	4 10 1	June and December	..	..
£7,716,000	$100	7%	Commercial Cable Capital Stock	135	140	135	140	5 0 0	April and October	..	..
16,000	10	8/0	Cuba Submarine	11	12	11½	12½	6 8 0	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	18	19	18	19	5 5 3	" "	18	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2⅜	3⅛	2⅜	3⅛	4 11 5	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	8⅛	9⅛	8⅛	9⅛	5 5 3	" "	..	..
60,710	20	3/6	Direct United States	11⅜	11⅝	11	11½	6 4 5	Jan., Apr., July, Oct.	11⅝	11
400,000	10	2/6	Eastern	14⅜	15⅛	14⅜	15	5 4 0	" "	15⅛	14⅞
70,000	10	6%	Do. 6 per Cent. Preference	16	16½	15½	16½	3 12 9	" "	16½	15¼
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	114	117	115	118	3 7 10	May and November	117	115½
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	108	111	4 10 1	February & August	108	..
250,000	10	2/6	Eastern Extension	15⅛	15⅜	15	15½	4 11 10	Jan., Apr., July, Oct.	15⅜	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	112	115	113	116	3 9 0	February & August	114⅜	112⅝
£70 630	100	5%	Do. 5 p. c.(Austln. Gov. Sub.) Debs 1900	102	105	102	105	4 15 3	January and July	103½	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	101	104	101	104	4 16 2	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	101	104	101	104	3 16 11	February & August	..	..
£200,000	£25	..	Do. 4% Mauritius Sub. Debs.	104⅞	107⅞	104⅞	107⅞	..	May and November	106	..
180,227	10	1/6	Globe Telegraph and Trust	9⅜	9⅝	8⅝	8¾	5 1 5	Jan., Apr., July, Oct.	9⅝	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	15⅛	15⅝	15	15½	3 18 8	" "	15⅝	1⅞
150,000	10	5/0	Great Northern	20	20½	20	20½	4 3 0	Jan., April, and July	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	103	106	103	106	4 14 4	March & September	..	..
17,000	25	37/6	Indo-European	40	43	41	44	5 13 8	May and November	42½	41½
37,548	10	4/0	London Platino-Brazilian	4	6	4	6	3 6 8	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	..	..
£100,000	£100	4%	Pacific European Telegh. 4% Guar. Debs. "Red" 1942	101	104	102	105	3 16 11	..	..	..
11,802	8	4/0	Reuter's	5½	6½	5½	6½	..	April and October	..	..
3,381	£100 Cert.	35/0	Submarine Cables Trust 6 per Cent.	115	120	113	118	5 1 8	" "	..	..
15,609	10	5/0	West African Telegraph	5½	6½	5½	6½	7 13 10	January and July	..	..
£260,900	100	5%	Do. 5 per Cent. Debentures	98	101	98	101	4 19 0	March & September	..	..
30,000	10	2/0	West Coast of America	2	3	2	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	99	103	99	103	7 15 4	June and December	..	..
88,321	10	6d.	West India and Panama	1½	1⅝	1½	1⅝	..	..	1⅝	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10⅝	10
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9	10	9	10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	106	109	106	109	4 11 9	June and December	..	..
64,242	15	4/6	Western and Brazilian	6⅜	7⅛	6⅜	7⅛	5 3 8	May and November	7⅛	..
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	5	5½	5⅜	6⅛	..	..	6⅜	5⅜
33,129	7½	4/6	Do. 5 per Cent. Deferred	1½	1⅝	1⅜	1⅝	..	..	..	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 13 2	February & August	..	..
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	..	..
$1,214,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage Building	115	120	115	120	5 16 8	May and November	..	..
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	102	105	102	105	5 14 3	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	2	3	2	3	..	..	..	..
22,850	10/0	3½d.	Consolidated Telephone Const. & Maintenance	1 1/16	1 1/16	1 1/16	1 1/16	..	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/16	1/16	1/16	1/16	7 18 2	Yearly	..	..
458,867	5	2/6	National	4⅜	4⅝	4⅜	4⅝	5 2 7	June and December	4⅞	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14	15	13½	14½	4 2 9	" "	14	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	13½	14½	13½	14½	4 2 9	" "	14½	..
90,950	5	2/0	Do. 5% Non-Cumulative 3rd Pref.	5⅛	5⅝	5⅛	5⅛	4 10 11	..	5 1/16	5⅜
726,477	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully paid)	112	114	113	115	3 18 3	January and July	114	113½
58,000	5	1/0	United River Plate	2	2¼	2	2¼	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	11½	11¾	11½	11¾	..	..	11¾	..
20,000	10	5/4	Do. 6 per Cent. Cumulative Pref. (£4 paid)	12½	13	12½	13½	5 2 7	..	13½	12⅛
19,900	£5	..	Electricity Supply Co. for Spain	..		..		..	..	..	..
£150,000	£5	..	Electricity Supply Company Ordinary	5	5½	..		..	..	..	..
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	..	..	..
8,322	£5	..	House to House Electric	..		..		..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		..	January and July	..	..
30,000	£5	3/4 '92	Liverpool Electric Supply (£3 10s. paid)	4½	4½	4½	4½	..	..	..	..
15,000	£5	5/0 '92	Do. (fully paid)	6 3/16	6 7/16	6 3/16	6 7/16	..	..	..	..
111,000	5	..	London Electric Supply	¾	1	¾	1	..	..	..	..
49,900	£10	4/0	Metropolitan Electric Supply (fully paid)	6⅞	7½	7	7½	2 13 4	..	7½	7
£100,000	Stock	5%	Do. 5 per Cent. Debs. (Bonds of £10, £20, & £40)	104	107	104	107	4 13 6	June and December	106	..
6,452	£10	..	Notting Hill Electric	5	6	5	6	..	..	..	..
19,980	£5	9½%	St. James' and Pall Mall	6½	6⅞	6	6½	..	..	6¼	6⅛
20,000	£5	7%	Do. 7 per Cent. Preference	8	8½	8	8½	4 2 4	..	8½	..
59,900	5	1/6	Westminster Electric Supply (fully paid)	5	5½	5	5½	3 3 8	..	5½	5
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	2/1	Brush Electrical Engineering	2⅜	3	2⅞	3⅛	5 15 2	..	3	2 1/16
75,000	2	6%	Do. 6 per Cent. Preference	2⅛	2⅜	2⅛	2⅜	5 1 1	..	2⅛	2 1/16
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	107	109	107	109	4 2 7	March & September	108⅜	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	3½	4½	3½	4½	..	January and July	..	..
12,139	5	..	Edison and Swan United	..		..		..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	..	..
49,900	10	12/0	Electric Construction	1⅞	2⅛	1⅞	2⅛	..	..	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜	½	⅜	½	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1	2	¾	1½	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha &c., Works	21½	22½	21½	22½	5 11 1	February & August	22½	22
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	101	103	101	103	4 7 5	March & September	..	..
11,334	£10	6/4	International Okonite Ordinary	1	2	1	2	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	..		..		..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/0	4/0	3/0	4/0	..	..	..	..
78,949	5	1/9	Swan United (£3. 10s. paid)	2	2¼	2	2¼	13 19 8	May and November	2⅛	..
37,350	12	12/0	Telegraph Construction and Maintenance	31	33	32	34	5 5 11	March and July	33	32⅝
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July	..	..
39,639	£5	..	Woodhouse and Rawson Ordinary (£3. 15s. paid)	..		..		..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	½%	City and South London Railway	30	35	30	35	2 2 6	May and November	..	..
37,500	£10	..	Liverpool Overhead Railway	5⅛	5⅝	5⅛	5⅝	..	..	..	..

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